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Executive Summary

This report identifies the Depth of Knowledge Levels (DOK) of the Michigan Science Content Expectations aligned to the DOK levels of the Webb Alignment Model. The DOK Levels are Recall and Reproduction, Skills and Concepts, Strategic Thinking, and Extended Thinking. Eight science educators and one facilitator participated in this study. Four of the participants were Michigan science teachers, and four of the participants were science educators from outside of the state of Michigan. This study was conducted July 28-29, 2009 at the West Campus of Lansing Community College, Lansing Michigan.

The 325 K-7 Science Content Expectations were coded as follows: DOK 1 – 209, DOK 2 – 91, DOK 3 – 25, DOK 4 – 0 The 477 High School Science Content Expectations were coded as follows: DOK 1 – 239, DOK 2 – 189, DOK 3 – 49, DOK 4 – 0.

Introduction

Depth-of-Knowledge measures the cognitive complexity of the knowledge elicited from science content expectations within the context area of what students are expected to know and do as stated in the standards. It indicates the level of cognitive complexity required for the student to meet the content expectations, not the difficulty of mastering the knowledge

The assigning of DOK levels to the Michigan Science Content Expectations took place over a two day period. Four of the eight reviewers were teachers from the state of Michigan who were familiar with the development of the Science Content Expectations. The other four reviewers were from outside the state of Michigan who were familiar with the National Science Content Standards and had experience with aligning standards to DOK levels. The facilitator has conducted science alignment studies using the Webb Alignment Model in over 15 states.

During the morning of the first day all reviewers were trained in the use of the Webb Alignment Model to assign DOK levels to standards. The Webb Alignment Training materials were used to train participants. Training included explanations of the four DOK Levels, as well as practice in determining DOK levels of sample science standards.

After training all reviewers examined the Standard Statements, Content Statements which describe the Prerequisite, Essential, Core, and Recommended science content understanding for that standard, and the Performance Expectations which describe Prerequisite, Essential, Core, and Recommended Performances for that standard. After reading each standard statement, content statement and performance expectation reviewers individually assigned a DOK level to each Performance Expectation. After each reviewer completes this task all reviewers come together to agree on a consensus DOK for each of the Performance Expectations. With the Group Leader facilitating, each team of reviewers participated in the consensus process by discussing, as a group, the depth-of-knowledge values they assigned to each of the objectives. This process is an opportunity for all reviewers to explain why they assigned a particular DOK level and to demonstrate how it applies to the objective. The Group Leader recorded and entered the results of the consensus process on the Web Alignment Tool's website

ALLIGNMENT OF

MICHIGAN SCIENCE CONTENT EXPECTATIONS

TO DOK LEVELS

Prepared by
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August, 2008

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Alignment Criteria used for this Analysis

WAT Science DOK Levels

Please note that, in the sciences, "knowledge" can refer both to content knowledge and knowledge of scientific processes. This distinction in the meaning of knowledge is consistent with the *National Science Education Standards* (NSES), which terms "Science as Inquiry" as its first Content Standard.

Level 1 (Recall and Reproduction) requires the recall of information, such as a fact, definition, term, or a simple procedure, as well as performance of a simple science process or procedure. Level 1 only requires students to demonstrate a rote response, use a well-known formula, follow a set procedure (like a recipe), or perform a clearly defined series of steps. A "simple" procedure is well-defined and typically involves only one step. Verbs such as "identify," "recall," "recognize," use," "calculate," and that can be directly translated into and solved by a formula are considered Level 1. Verbs such as "describe" and "explain" could be classified at different DOK levels, depending on the complexity of what is to be described and explained.

A student answering a Level 1 item either knows the answer or does not: that is, the item does not need to be "figured out" or "solved." In other words, if the knowledge necessary to answer an item automatically provides the answer to it, then the item is at Level 1. If the knowledge needed to answer the item is not automatically provided in the stem, the item is at least at Level 2. Some examples that represent, but do not constitute all of Level 1 performance are:

- **Recall or recognize a fact, term, or property.**
- Represent in words or diagrams a scientific concept or relationship.
- Provide or recognize a standard scientific representation for simple phenomenon.
- Perform a routine procedure, such as measuring length.

Level 2 (Skills and Concepts) includes the engagement of some mental processing beyond recalling or reproducing a response. The content knowledge or process involved is **more complex** than in Level 1. Items require students to make some decisions as to how to approach the question or problem. Keywords that generally distinguish a Level 2 item include "classify," "organize," "estimate," "make observations," "collect and display data," and "compare data." These actions imply **more than one step**. For example, to compare data requires first identifying characteristics of the objects or phenomena and then grouping or ordering the objects. Level 2 activities include making observations and collecting data; classifying, organizing, and comparing data; and organizing and displaying data in tables, graphs, and charts. Some action verbs, such as "explain," "describe," or "interpret," could be classified at different DOK levels, depending on the complexity of the action. For example, interpreting information from a simple graph, requiring reading information from the graph, is a Level 2. An item that requires interpretation from a complex graph, such as making decisions regarding features of the graph that need to be considered and how information from the graph can be aggregated, is at Level 3. Some examples that represent, but do not constitute all of Level 2 performance, are:

- Specify and explain the relationship between facts, terms, properties, or variables.
- Describe and explain examples and non-examples of science concepts.
- Select a procedure according to specified criteria and perform it.
- Formulate a routine problem, given data and conditions.
- Organize, represent, and interpret data.

Level 3 (Strategic Thinking) requires reasoning, planning, using evidence, and a higher level of thinking than the previous two levels. The cognitive demands at Level 3 are complex and abstract. The complexity does not result only from the fact that there could be multiple answers, a possibility for both Levels 1 and 2, but because the multi-step task requires more demanding reasoning. In most instances, requiring students to explain their thinking is at Level 3; requiring a very simple explanation or a word or two should be at Level 2. An activity that has more than one possible answer and requires students to justify the response they give would most likely be a Level 3. Experimental designs in Level 3 typically involve more than one dependent variable. Other Level 3 activities include drawing conclusions from observations; citing evidence and developing a logical argument for concepts; explaining phenomena in terms of concepts; and using concepts to solve non-routine problems. Some examples that represent, but do not constitute all of Level 3 performance, are:

- Identify research questions and design investigations for a scientific problem.
- Solve non-routine problems
- Develop a scientific model for a complex situation.
- Form conclusions from experimental data.

Level 4 (Extended Thinking) involves high cognitive demands and complexity. Students are required to make several connections—relate ideas within the content area or among content areas—and have to select or devise one approach among many alternatives to solve the problem. Many on-demand assessment instruments will not include any assessment activities that could be classified as Level 4. However, standards, goals, and objectives can be stated in such a way as to expect students to perform extended thinking. "Develop generalizations of the results obtained and the strategies used and apply them to new problem situations," is an example of a Grade 8 objective that is a Level 4. Many, but not all, performance assessments and open-ended assessment activities requiring significant thought will be Level 4.

Level 4 requires complex reasoning, experimental design and planning, and probably will require an extended period of time either for the science investigation required by an objective, or for carrying out the multiple steps of an assessment item. However, the extended time period is not a distinguishing factor if the required work is only repetitive and does not require applying significant conceptual understanding and higher-order thinking. For example, if a student has to take the water temperature from a river each day for a month and then construct a graph, this would be classified as a Level 2 activity. However, if the student conducts a river study that requires taking into consideration a number of variables, this would be a Level 4. Some examples that represent, but do not constitute all of a Level 4 performance are:

- Based on data provided from a complex experiment that is novel to the student, deduct the fundamental relationship between several controlled variables.
- Conduct an investigation, from specifying a problem to designing and carrying out an experiment, to analyzing its data and forming conclusions.

Findings:

The tables below summarized the DOK Levels assigned to the K-7, Biology, Chemistry, Earth Science, and Physics Michigan Science Content Expectations. Following these two tables are the DOK Levels for each elementary grade and high school course

Table 1: DOK Level of K-7 Michigan Science Content Expectations

	DOK Level				# of Perf.
Grade	1	2	3	4	Desc.
K	14	5	1	0	20
1	20	8	1	0	29
2	21	6	1	0	28
3	30	19	1	0	50
4	32	14	1	0	47
5	26	12	6	0	44
6	30	12	7	0	49
7	36	15	7	0	58
TOTALS	209	91	25	0	325

Table 2: DOK Levels of High School Michigan Science Content Expectations

	DOK Level				# of Perf.
Course	1	2	3	4	Desc.
Biology	44	62	13	0	119
Chemistry	71	49	12	0	132
Earth Science	41	44	12	0	97
Physics	83	34	12	0	129
TOTALS	239	189	49	0	477

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.E.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation.	
S.IP.00.11	Make purposeful observation of the natural world using the appropriate senses	2
S.IP.00.12	Generate questions based on observations	2
S.IP.00.13	Plan and conduct simple investigations.	3
S.IP.00.14	Manipulate simple tools (for example: hand lens, pencils, balances, non-standard objects for measurement) that aid observation and data collection.	1
S.IP.00.15	Make accurate measurements with appropriate (non-standard) units for the measurement tool.	1
S.IP.00.16	Construct simple charts from data and observations.	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.E.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations	
S.IA.00.12	Share ideas about science through purposeful conversation	1
S.IA.00.13	Communicate and present findings of observations	1
S.IA.00.14	Develop strategies for information gathering (ask an expert, use a book, make observations, conduct simple investigations, and watch a video)	1
Science Processes	**Reflection and Social Implications**	
Statement S.RS.E.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision making and the application of science throughout history and within society.	
S.RS.00.11	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
Physical Science	**Force and Motion**	
Statement P.FM.E.1	A position of an object can be described by locating the object relative to other objects or a background. The description of the motion of an object from one observer's view may be different from that reported from a different observer's view	
P.FM.00.11	Compare the position of an object (for example: above, below, in front of, behind, on) in relation to other objects around it	1
P.FM.00.12	Describe the motion of an object (for example: away from or closer to) from different observers' views.	2
Statement P.FM.E.2	Gravity- Earth pulls down on all objects with a force called gravity. With very few exceptions, objects fall to the ground no matter where the object is on the Earth.	
P.FM.00.21	Observe how objects fall toward the earth	1

GLCE Code	Expectation	DOK
Statement P.FM.E.3	Force- A force is either a push or a pull. The motion of objects can be changed by forces. The size of the change is related to the size of the force. The change is also related to the weight (mass) of the object on which the force is being exerted. When an object does not move in response to a force, it is because another force is being applied by the environment.	
P.FM.00.31	Demonstrate pushes and pulls.	1
P.FM.0.32	Observe that objects initially at rest will move in the direction of the push or pull	1
P.FM.00.33	Observe how pushes and pulls can change the speed or direction of moving objects.	1
P.FM.00.34	Observe how shape (for example: cone, cylinder, sphere), size, and weight of an object can affect motion.	1
Life Science	**Organization of Living Things**	
Statement L.OL.E.1	Organisms have basic needs. Animals and plants need air, water, and food. Plants also require light. Plants and animals use food as a source of energy and as a source of building material for growth and repair.	
L.OL.00.11	Identify that living things have basic needs	1
L.OL.00.12	Identify and compare living and nonliving things	2
Earth Science	**Solid Earth**	
Statement E.SE.E.1	Earth Materials- Earth materials that occur in nature include rocks, minerals, soils, water, and the gases of the atmosphere. Some Earth materials have properties which sustain plant and animal life.	
E.SE.00.11	Identify Earth materials (air, water, soil) that are used to grow plants.	1

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.E.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S IP 01 11	Make purposeful observation of the natural world using the appropriate senses.	2
S.IP.01 12	Generate questions based on observations	2
S IP 01.13	Plan and conduct simple investigations	3
S.IP.01 14	Manipulate simple tools (for example: hand lens, pencils, balances, non-standard objects for measurement) that aid observation and data collection.	1
S.IP.01 15	Make accurate measurements with appropriate (non-standard) units for the measurement tool.	1
S.IP.01 16	Construct simple charts from data and observations	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.E.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations.	
S IA.01 12	Share ideas about science through purposeful conversation	1
S.IA 01 13	Communicate and present findings of observations	1
S IA.01 14	Develop strategies for information gathering (ask an expert, use a book, make observations, conduct simple investigations, and watch a video)	1
Science Processes	**Reflection and Social Implications**	
Statement S.RS.E.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision making and the application of science throughout history and within society.	
S.RS.01.11	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S RS 01 12	Recognize that science investigations are done more than one time	1
Physical Science	**Properties of Matter**	
Statement P.PM.E.1	Physical Properties- All objects and substances have physical properties that can be measured	
P PM 01 11	Demonstrate the ability to sort objects according to observable attributes such as color, shape, size, sinking or floating	2
Statement P.PM.E.2	States of Matter- Matter exists in several different states: solids, liquids and gases. Each state of matter has unique physical properties. Gases are easily compressed but liquids and solids do not compress easily. Solids have their own particular shapes, but liquids and gases take the shape of the container	
P.PM.01 21	Demonstrate that water as a solid keeps its own shape (ice).	1
P PM 01 22	Demonstrate that water as a liquid takes on the shape of various containers.	1

GLCE Code	Expectation	DOK
Statement P.PM.E.3	Magnets- Magnets can repel or attract other magnets. Magnets can also attract certain non-magnetic objects at a distance.	
P.PM.01.31	Identify materials that are attracted by magnets.	1
P PM 01.32	Observe that like poles of a magnet repel and unlike poles of a magnet attract	1
Life Science	**Organization of Living Things**	
Statement L.OL.E.1	Life Requirements- Organisms have basic needs. Animals and plants need air, water, and food. Plants also require light. Plants and animals use food as a source of energy and as a source of building material for growth and repair.	
L.OL.01.13	Identify the needs of animals	1
Statement L.OL.E.2	Life Cycles- Plants and animals have life cycles. Both plants and animals begin life and develop into adults, reproduce, and eventually die. The details of this life cycle are different for different organisms.	
L OL 01.21	Describe the life cycle of animals including the following stages: egg, young, adult; egg, larva, pupa, adult	1
Life Science	**Heredity**	
Statement L.HE.01.11	Observable Characteristics- Plants and animals share many, but not all, characteristics of their parents.	
L.HE.01.11	Identify characteristics (for example: body coverings, beak shape, number of legs, body parts) that are passed on from parents to young.	1
L HE 01.12	Classify young animals based on characteristics that are passed on from parents (for example: dogs/puppies, cats/kittens, cows/calves, chicken/chicks)	2
Earth Science	**Earth Systems**	
Statement E.ES.E.1	Solar Energy- The sun warms the land, air and water and helps plants grow	
E.ES.01.11	Identify the sun as the most important source of heat which warms the land, air, and water of the Earth	1
E ES 01.12	Demonstrate the importance of sunlight and warmth in plant growth	2
Statement E.ES.E.2	Weather- Weather changes from day to day and over the seasons	
E ES 01.21	Compare daily changes in the weather related to temperature (cold, hot, warm, cool); cloud cover (cloudy, partly cloudy, foggy) precipitation (rain, snow, hail, freezing rain); wind (breezy, windy, calm).	2
E.ES.01.22	Describe and compare weather related to the four seasons in terms of temperature, cloud cover, precipitation, and wind.	2
E.ES.01.23	Describe severe weather events.	1
E ES 01.24	Describe precautions that should be taken for human safety during severe weather conditions (thunderstorms, lightning, tornadoes, high winds, blizzards, hurricanes)	1

GLCE Code	Expectation	DOK
Statement E.ES.E.3	Weather Measurement- Scientists use tools for observing, recording, and predicting weather changes.	
E.ES.01.31	Identify the tools that might be used to measure temperature, precipitation, cloud cover and wind	1
E.ES.01.32	Observe and collect data of weather conditions over a period of time	1
Earth Science	**Solid Earth**	
Statement E.SE.E.1	Earth Materials- Earth materials that occur in nature include rocks, minerals, soils, water, and the gases of the atmosphere Some Earth materials have properties which sustain plant and animal life	
E.SE.01.12	Describe how Earth materials contribute to the growth of plant and animal life	1

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.E.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation.	
S.IP.02.11	Make purposeful observation of the natural world using the appropriate senses.	2
S.IP.02.12	Generate questions based on observations	2
S.IP.02.13	Plan and conduct simple investigations	3
S.IP.02.14	Manipulate simple tools (for example: hand lens, pencils, balances, non-standard objects for measurement) that aid observation and data collection.	1
S.IP.02.15	Make accurate measurements with appropriate (non-standard) units for the measurement tool	1
S.IP.02.16	Construct simple charts from data and observations	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.E.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations	
S.IA.02.12	Share ideas about science through purposeful conversation	1
S.IA.02.13	Communicate and present findings of observations.	1
S.IA.02.14	Develop strategies and skills for information gathering and problem solving (books, internet, ask an expert, observation, investigation, technology tools)	1
Science Processes	**Reflection and Social Implications**	
Statement S.RS.E.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision making and the application of science throughout history and within society	
S.RS.02.11	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S.RS.02.13	Recognize that when a science investigation is done the way it was done before, similar results are expected.	1
S.RS.02.15	Use evidence when communicating scientific ideas.	2
S.RS.02.16	Identify technology used in everyday life	1
Physical Science	**Properties of Matter**	
Statement P.PM.E.1	Physical Properties- All objects and substances have physical properties that can be measured.	
P.PM.02.12	Describe objects and substances according to their properties (color, size, shape, texture, hardness, liquid or solid, sinking or floating).	1
P.PM.02.13	Measure the length of objects using rulers (centimeters) and meter sticks (meters).	1
P.PM.02.14	Measure the volume of liquids using common measuring tools (measuring cups, measuring spoons).	1
P.PM.02.15	Compare the weight of objects using balances.	2

GLCE Code	Expectation	DOK
Statement P.PM.E.4	Material Composition- Some objects are composed of a single substance, while other objects are composed of more than one substance	
P PM.02.41	Classify objects as single substances (ice, silver, sugar, salt) or mixtures (salt and pepper, mixed dry beans).	2
Life Science	**Organization of Living Things**	
Statement L.OL.E.1	Life Requirements- Organisms have basic needs. Animals and plants need air, water, and food. Plants also require light. Plants and animals use food as a source of energy and as a source of building material for growth and repair.	
L OL.02.14	Identify the needs of plants.	1
Statement L.OL.E.2	Life Cycles- Plants and animals have life cycles. Both plants and animals begin life and develop into adults, reproduce, and eventually die. The details of this life cycle are different for different organisms.	
L OL.02.22	Describe the life cycle of familiar flowering plants including the following stages: seed, plant, flower, and fruit	1
Life Science	**Heredity**	
Statement L.HE.E.1	Observable Characteristics- Plants and animals share many, but not all, characteristics of their parents.	
L HE.02.13	Identify characteristics of plants (for example: leaf shape, flower type, color, size) that are passed on from parents to young.	1
Earth Science	**Solid Earth**	
Statement E.SE.E.2	Surface Changes- The surface of Earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.	
E SE.02.21	Describe the major landforms of the surface of the Earth (mountains, plains, plateaus, valleys, hills).	1
Earth Science	**Fluid Earth**	
Statement E.FE.E.1	Water- Water is a natural resource and is found under the ground, on the surface of the earth, and in the sky. It exists in three states (liquid, solid, gas) and can go back and forth from one form to another.	
E FE 02.11	Identify water sources (wells, springs, lakes, rivers, oceans)	1
E FE.02.12	Identify household uses of water (drinking, cleaning, food preparation)	1
E FE 02.13	Describe the properties (visible, flowing, melting, dew) of water as a liquid (lakes, rivers, streams, oceans)	1
E FE.02.14	Describe the properties (hard, visible, freezing, ice) of water as a solid (ice, snow, iceberg, sleet, hail)	1
Statement E.FE.E.2	Water Movement- Water moves in predictable patterns.	
E FE 02.21	Describe how rain collects on the surface of the Earth and flows downhill into bodies of water (streams, rivers, lakes, oceans) or into the ground.	1
E FE.02.22	Describe the major bodies of water on the Earth's surface (lakes, ponds, oceans, rivers, streams)	1

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.E.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S.IP.03.11	Make purposeful observation of the natural world using the appropriate senses	2
S.IP.03.12	Generate questions based on observations	2
S.IP.03.13	Plan and conduct simple and fair investigations	3
S.IP.03.14	Manipulate simple tools that aid observation and data collection (for example: hand lens, balance, ruler, meter stick, measuring cup, thermometer, spring scale, stop watch/timer)	1
S.IP.03.15	Make accurate measurements with appropriate units (centimeters, meters, Celsius, grams seconds, minutes) for the measurement tool	1
S.IP.03.16	Construct simple charts and graphs from data and observations	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.E.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations	
S.IA.03.11	Summarize information from charts and graphs to answer scientific questions	2
S.IA.03.12	Share ideas about science through purposeful conversation in collaborative groups	1
S.IA.03.13	Communicate and present findings of observations and investigations	1
S.IA.03.14	Develop research strategies and skills for information gathering and problem solving	2
S.IA.03.15	Compare and contrast sets of data from multiple trials of a science investigation to explain reasons for differences	2
Science Processes	**Reflection and Social Implications**	
Statement S.RS.E.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision making and the application of science throughout history and within society	
S.RS.03.11	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities	1
S.RS.03.14	Use data/samples as evidence to separate fact from opinion	2
S.RS.03.15	Use evidence when communicating scientific ideas	2
S.RS.03.16	Identify technology used in everyday life	1
S.RS.03.17	Identify current problems that may be solved through the use of technology	1

GLCE Code	Expectation	DOK
S.RS.03.18	Describe the effect humans and other organisms have on the balance of the natural world	1
S.RS.03.19	Describe how people have contributed to science throughout history and across cultures.	1
Physical Science	**Force and Motion**	
Statement P.FM.E.2	Gravity- Earth pulls down on all objects with a force called gravity. With very few exceptions, objects fall to the ground no matter where the object is on the Earth	
P.FM.03.22	Identify the force that pulls objects towards the Earth	1
Statement P.FM.E.3	Force- A force is either a push or a pull. The motion of objects can be changed by forces. The size of the change is related to the size of the force. The change is also related to the weight (mass) of the object on which the force is being exerted. When an object does not move in response to a force, it is because another force is being applied by the environment.	
P.FM.03.35	Describe how a push or a pull is a force	1
P.FM.03.36	Relate a change in motion of an object to the force that caused the change of motion.	2
P.FM.03.37	Demonstrate how the change in motion of an object is related to the strength of the force acting upon the object and to the mass of the object	2
P.FM.03.38	Demonstrate when an object does not move in response to a force, it is because another force is acting on it.	1
Statement P.FM.E.4	Speed- An object is in motion when its position is changing. The speed of an object is defined by how far it travels divided by the amount of time it took to travel that far.	
P.FM.03.41	Compare and contrast the motion of objects in terms of direction	2
P.FM.03.42	Identify changes in motion (change direction, speeding up, slowing down)	1
P.FM.03.43	Calculate the speed of an object based on the distance it travels divided by the amount of time it took to travel that distance.	1
Physical Science	**Energy**	
Statement P.EN.E.1	Forms of Energy- Heat, electricity, light, and sound are forms of energy.	
P.EN.03.11	Identify light and sound as forms of energy.	1
Statement P.EN.E.2	Light Properties- Light travels in straight lines. Shadows result from light not being able to pass through an object. When light travels at an angle from one substance to another (air and water), it changes direction.	
P.EN.03.21	Demonstrate that light travels in a straight line and that shadows are made by placing an object in a path of light.	1
P.EN.03.22	Demonstrate what happens to light when it travels from water to air (straw half in water looks bent)	1
Statement P.EN.E.3	Sound- Vibrating objects produce sound. The pitch of sound varies by changing the rate of vibration.	
P.EN.03.31	Relate sounds to their sources of vibrations (for example: a musical note produced by a vibrating guitar string, the sounds of a drum made by the vibrating drum head).	1
P.EN.03.32	Distinguish the effect of fast or slow vibrations as pitch.	2

GLCE Code	Expectation	DOK
Physical Science	**Properties of Matter**	
Statement P.PM.E.5	Conductive and Reflective Properties- Objects vary to the extent they absorb and reflect light energy and conduct heat and electricity	
P.PM.03.51	Demonstrate how some materials are heated more than others by light that shines on them.	1
P.PM.03.52	Explain how we need light to see objects: light from a source reflects off objects and enters our eyes	1
Life Science	**Organization of Living Things**	
Statement L.OL.E.3	Structures and Functions- Organisms have different structures that serve different functions in growth, survival, and reproduction	
L.OL.03.31	Describe the function of the following plant parts: flower, stem, root and leaf	1
L.OL.03.32	Identify and compare structures in animals used for controlling body temperature, support, movement, food-getting, and protection (for example: fur, wings, teeth, claws).	2
Statement L.OL.E.4	Classification- Organisms can be classified on the basis of observable characteristics.	
L.OL.03.41	Classify plants on the basis of observable physical characteristics (roots, leaves, stems, and flowers).	2
L.OL.03.42	Classify animals on the basis of observable physical characteristics (backbone, skin, shell, limbs, scales)	2
Life Science	**Evolution**	
Statement L.EV.E.1	Environmental Adaptation- Different kinds of organisms have characteristics that help them to live in different environments.	
L.EV.03.11	Relate characteristics and functions of observable parts in a variety of plants that allow them to live in their environment (for example: leaf shape, thorns, odor, color)	2
L.EV.03.12	Relate characteristics and functions of observable body parts to the ability of animals to live in their environment (for example: sharp teeth, claws, color, body covers).	2
Earth Science	**Earth Systems**	
Statement E.ES.E.4	Natural Resources- The supply of many natural resources is limited Humans have devised methods for extending their use of natural resources through recycling, reuse, and renewal.	
E.ES.03.41	Identify natural resources (metals, fuels, fresh water, farmland, and forests)	1
E.ES.03.42	Classify renewable (fresh water, farmland, forests) and non- renewable (fuels, metals) resources	2
E.ES.03.43	Describe ways humans are protecting, extending, and restoring resources (recycle, reuse, reduce, renewal).	1
E.ES.03.44	Recognize that paper, metal, glass, and some plastics can be recycled.	1
Statement E.ES.E.5	Human Impact- Humans depend on their natural and constructed environment Humans change environments in ways that are helpful or harmful for themselves and other organisms	
E.ES.03.51	Describe ways humans are dependent on the natural environment (forests, water, clean air, earth materials) and constructed environments (homes, neighborhoods, shopping malls, factories, and industry).	1
E.ES.03.52	Describe helpful or harmful effects of humans on the environment (garbage, habitat destruction, land management, renewable and non-renewable resources).	1

GLCE Code	Expectation	DOK
Earth Science	**Solid Earth**	
Statement E.SE.E.1	Earth Materials- Earth materials that occur in nature include rocks, minerals, soils, water, and the gases of the atmosphere Some Earth materials have properties which sustain plant and animal life	
E.SE.03.13	Recognize and describe different types of earth materials (mineral, rock, clay, boulder, gravel, sand, soil).	2
E.SE.03.14	Recognize that rocks are made up of minerals	1
Statement E.SE.E.2	Surface Changes- The surface of Earth changes Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes.	
E.SE.03.22	Identify and describe natural causes of change in the Earth's surface (erosion, glaciers, volcanoes, landslides, and earthquakes).	1
Statement E.SE.E.3	Using Earth Materials- Some Earth materials have properties that make them useful either in their present form or designed and modified to solve human problems. They can enhance the quality of life as in the case of materials used for building or fuels used for heating and transportation.	
E.SE.03.31	Identify Earth materials used to construct some common objects (for example: bricks, buildings, roads, glass)	1
E.SE.03.32	Describe how materials taken from the Earth can be used as fuels for heating and transportation.	1

Fourth Grade Science Alignment Record Science GLCE v.12.07

MICHIGAN Department of Education

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.E.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S.IP.04.11	Make purposeful observation of the natural world using the appropriate senses	2
S.IP.04.12	Generate questions based on observations	2
S.IP.04.13	Plan and conduct simple and fair investigations.	3
S.IP.04.14	Manipulate simple tools that aid observation and data collection (for example: hand lens, balance, ruler, meter stick, measuring cup, thermometer, spring scale, stop watch/timer, graduated cylinder/beaker)	1
S.IP.04.15	Make accurate measurements with appropriate units (centimeters, meters, Celsius, grams, seconds, minutes) for the measurement tool	1
S.IP.04.16	Construct simple charts and graphs from data and observations	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.E.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations	
S.IA.04.11	Summarize information from charts and graphs to answer scientific questions.	2
S.IA.04.12	Share ideas about science through purposeful conversation in collaborative groups	1
S.IA.04.13	Communicate and present findings of observations and investigations.	1
S.IA.04.14	Develop research strategies and skills for information gathering and problem solving.	2
S.IA.04.15	Compare and contrast sets of data from multiple trials of a science investigation to explain reasons for differences	2
Science Processes	**Reflection and Social Implications**	
Statement S.RS.E.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision making and the application of science throughout history and within society	
S.RS.04.11	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S.RS.04.14	Use data/samples as evidence to separate fact from opinion	2
S.RS.04.15	Use evidence when communicating scientific ideas	2
S.RS.04.16	Identify technology used in everyday life	1
S.RS.04.17	Identify current problems that may be solved through the use of technology	1
S.RS.04.18	Describe the effect humans and other organisms have on the balance of the natural world.	1
S.RS.04.19	Describe how people have contributed to science throughout history and across cultures.	1

GLCE Code	Expectation	DOK
Physical Science	**Energy**	
Statement P.EN.E.1	Forms of Energy- Heat, electricity, light, and sound are forms of energy	
P.EN.04.12	Identify heat and electricity as forms of energy	1
Statement P.EN.E.4	Energy and Temperature- Increasing the temperature of any substance requires the addition of energy.	
P.EN.04.41	Demonstrate how temperature can be increased in a substance by adding energy	1
P.EN.04.42	Describe heat as the energy produced when substances burn, certain kinds of materials rub against each other, and when electricity flows through wire.	1
P.EN.04.43	Describe how heat is produced through electricity, rubbing, and burning.	1
Statement P.EN.E.5	Electrical Circuits- Electrical circuits transfer electrical energy and produce magnetic fields.	
P.EN.04.51	Explain how electrical energy is transferred and changed through the use of a simple circuit.	2
P.EN.04.52	Create a simple working electromagnet and explain the conditions necessary to make the electromagnet.	2
Physical Science	**Properties of Matter**	
Statement P.PM.E.1	Physical Properties- All objects and substances have physical properties that can be measured	
P.PM.04.16	Measure the weight (spring scale) and mass (balances in grams or kilograms) of objects.	1
P.PM.04.17	Measure volumes of liquids and capacities of containers in milliliters and liters	1
P.PM.04.18	Demonstrate the use of centimeter cubes poured into a container to estimate the container's capacity.	1
Statement P.PM.E.2	States of Matter- Matter exists in several different states: solids, liquids, and gases. Each state of matter has unique physical properties. Gases are easily compressed, but liquids and solids do not compress easily. Solids have their own particular shapes, but liquids and gases take the shape of the container.	
P.PM.04.23	Compare and contrast the states (solids, liquids, gases) of matter.	2
Statement P.PM.E.3	Magnets- Magnets can repel or attract other magnets. Magnets can also attract certain non-magnetic objects at a distance.	
P.PM.04.33	Demonstrate magnetic field by observing the patterns formed with iron filings using a variety of magnets.	1
P.PM.04.34	Demonstrate that non-magnetic objects are affected by the strength of the magnet and the distance away from the magnet.	1
Statement P.PM.E.5	Conductive and Reflective Properties- Objects vary to the extent they absorb and reflect light energy and conduct heat and electricity.	
P.PM.04.53	Identify objects that are good conductors or poor conductors of heat and electricity	1
Physical Science	**Changes in Matter**	
Statement P.CM.E.1	Changes in State- Matter can be changed from one state (liquid, solid, gas) to another and then back again. This may be caused by heating and cooling.	
P.CM.04.11	Explain how matter can change from one state (liquid, solid, gas) to another by heating and cooling.	1

GLCE Code	Expectation	DOK
Life Science	**Organization of Living Things**	
Statement L.OL.E.1	Life Requirements- Organisms have basic needs. Animals and plants need air, water, and food. Plants also require light. Plants and animals use food as a source of energy and as a source of building material for growth and repair.	
L.OL.04.15	Determine that plants require air, water, light, and a source of energy and building material for growth and repair	1
L.OL.04.16	Determine that animals require air, water, and a source of energy and building material for growth and repair	1
Life Science	**Evolution**	
Statement L.EV.E.2	Survival- Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing	
L.EV.04.21	Identify individual differences (for example: color, leg length, size, wing size) in organisms of the same kind.	1
L.EV.04.22	Identify how variations in physical characteristics of individual organisms give them an advantage for survival and reproduction	1
Life Science	**Ecosystems**	
Statement L.EC.E.1	Interactions- Organisms interact in various ways including providing food and shelter to one another. Some interactions are helpful; others are harmful to the organism and other organisms.	
L.EC.04.11	Identify organisms as part of a food chain or food web.	1
Statement L.EC.E.2	Changed Environment Effects- When the environment changes, some plants and animals survive to reproduce; others die or move to new locations	
L.EC.04.21	Explain how environmental changes can produce a change in the food web	2
Earth Science	**Earth in Space and Time**	
Statement E.ST.E.1	Characteristics of Objects in the Sky- Common objects in the sky have observable characteristics	
E.ST.04.11	Identify common objects in the sky, such as the sun and the moon	1
E.ST.04.12	Compare and contrast the characteristics of the sun, moon and Earth, including relative distances and abilities to support life	2
Statement E.ST.E.2	Patterns of Objects in the Sky- Common objects in the sky have observable characteristics and predictable patterns of movement.	
E.ST.04.21	Describe the orbit of the Earth around the sun as it defines a year	1
E.ST.04.22	Explain that the spin of the Earth creates day and night	1
E.ST.04.23	Describe the motion of the moon around the Earth.	1
E.ST.04.24	Explain how the visible shape of the moon follows a predictable cycle which takes approximately one month.	1
E.ST.04.25	Describe the apparent movement of the sun and moon across the sky through day/night and the seasons	1

GLCE Code	Expectation	DOK
Statement E.SI.E.3	Fossils- Fossils provide evidence about the plants and animals that lived long ago and the nature of the environment at that time	
E.ST.04.31	Explain how fossils provide evidence of the history of the Earth.	1
E.ST.04.32	Compare and contrast life forms found in fossils and organisms that exist today	2

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.M.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S IP 05.11	Generate scientific questions based on observations, investigations, and research.	2
S.IP.05.12	Design and conduct scientific investigations.	3
S.IP.05 13	Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens) appropriate to scientific investigations.	1
S.IP 05 14	Use metric measurement devices in an investigation	1
S IP 05.15	Construct charts and graphs from data and observations	2
S IP.05.16	Identify patterns in data.	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.M.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations.	
S.IA.05.11	Analyze information from data tables and graphs to answer scientific questions	2
S IA 05.12	Evaluate data, claims, and personal knowledge through collaborative science discourse.	2
S IA 05 13	Communicate and defend findings of observations and investigations using evidence	3
S.IA.05 14	Draw conclusions from sets of data from multiple trials of a scientific investigation.	3
S.IA.05.15	Use multiple sources of information to evaluate strengths and weaknesses of claims, arguments, or data	3
Science Processes	**Reflection and Social Implications**	
Statement S.RS.M.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision-making and the application of science throughout history and within society.	
S.RS 05 11	Evaluate the strengths and weaknesses of claims, arguments, and data	3
S RS.05 12	Describe limitations in personal and scientific knowledge.	2
S RS.05.13	Identify the need for evidence in making scientific decisions	1
S.RS 05.15	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S.RS.05 16	Design solutions to problems using technology.	3
S RS.05.17	Describe the effect humans and other organisms have on the balance in the natural world	1
S.RS.05.19	Describe how science and technology have advanced because of the contributions of many people throughout history and across cultures.	1

GLCE Code	Expectation	DOK
Physical Science	**Force and Motion**	
Statement P.FM.M.2	Force Interactions- Some forces between objects act when the objects are in direct contact (touching), such as friction and air resistance, or when they are not in direct contact (not touching), such as magnetic force, electrical force, and gravitational force.	
P.FM.05.21	Distinguish between contact forces and non-contact forces.	1
P FM 05.22	Demonstrate contact and non-contact forces to change the motion of an object	1
Statement P.FM.M.3	Force- Forces have a magnitude and direction. Forces can be added. The net force on an object is the sum of all of the forces acting on the object. The speed and/or direction of motion of an object changes when a non-zero net force is applied to it. A balanced force on an object does not change the motion of the object (the object either remains at rest or continues to move at a constant speed in a straight line).	
P.FM.05.31	Describe what happens when two forces act on an object in the same or opposing directions.	1
P FM 05 32	Describe how constant motion is the result of balanced (zero net) forces	1
P.FM.05.33	Describe how changes in the motion of objects are caused by a non-zero net (unbalanced) force.	1
P.FM.05 34	Relate the size of change in motion to the strength of unbalanced forces and the mass of the object.	2
Statement P.FM.M.4	Speed- Motion can be described by a change in position relative to a point of reference. The motion of an object can be described by its speed and the direction it is moving. The position and speed of an object can be measured and graphed as a function of time.	
P FM 05 41	Explain the motion of an object relative to its point of reference	1
P.FM.05.42	Describe the motion of an object in terms of distance, time and direction, as the object moves, and in relationship to other objects	2
P FM 05.43	Illustrate how motion can be measured and represented on a graph	2
Life Science	**Organization of Living Things**	
Statement L.OL.M.4	Animal Systems- Multicellular organisms may have specialized systems that perform functions which serve the needs of the organism	
L.OL.05 41	Identify the general purpose of selected animal systems (digestive, circulatory, respiratory, skeletal, muscular, nervous, excretory, and reproductive).	1
L.OL.05.42	Explain how animal systems (digestive, circulatory, respiratory, skeletal, muscular, nervous, excretory, and reproductive) work together to perform selected activities	2
Life Science	**Heredity**	
Statement L.HE.M.1	Inherited and Acquired Traits - The characteristics of organisms are influenced by heredity and environment. For some characteristics, inheritance is more important; for other characteristics, interactions with the environment are more important	
L.HE.05.11	Explain that the traits of an individual are influenced by both the environment and the genetics of the individual	1
L HE 05 12	Distinguish between inherited and acquired traits.	1

GLCE Code	Expectation	DOK
Life Science	**Evolution**	
Statement L.EV.M.1	Species Adaptation and Survival- Species with certain traits are more likely than others to survive and have offspring in particular environments. When an environment changes, the advantage or disadvantage of the species' characteristics can change Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival.	
L.EV.05.11	Explain how behavioral characteristics (adaptation, instinct, learning, habit) of animals help them to survive in their environment.	1
L.EV.05.12	Describe the physical characteristics (traits) of organisms that help them survive in their environment	1
L.EV.05.13	Describe how fossils provide evidence about how living things and environmental conditions have changed	1
L.EV.05.14	Analyze the relationship of environmental change and catastrophic events (for example: volcanic eruption, floods, asteroid impacts, tsunami) to species extinction	2
Statement L.EV.M.2	Relationships Among Organisms- Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.	
L.EV.05.21	Relate degree of similarity in anatomical features to the classification of contemporary organisms	2
Earth Science	**Earth Systems**	
Statement E.ES.M.6	Seasons- Seasons result from annual variations in the intensity of sunlight and length of day due to the tilt of the axis of the Earth relative to the plane of its yearly orbit around the sun	
E.ES.05.61	Demonstrate using a model, seasons as the result of variations in the intensity of sunlight caused by the tilt of the Earth on its axis, and revolution around the sun.	1
E.ES.05.62	Explain how the revolution of the Earth around the sun defines a year.	1
Earth Science	**Earth in Space and Time**	
Statement E.ST.M.1	Solar System- The sun is the central and largest body in our solar system. Earth is the third planet from the sun in a system that includes other planets and their moons, as well as smaller objects, such as asteroids and comets	
E.ST.05.11	Design a model that describes the position and relationship of the planets and other objects (comets and asteroids) to the sun	1
Statement E.ST.M.2	Solar System Motion- Gravity is the force that keeps most objects in the solar system in regular and predictable motion	
E.ST.05.21	Describe the motion of planets and moons in terms of rotation on axis and orbits due to gravity.	1
E.ST.05.22	Explain moon phases as they relate to the position of the moon in its orbit around the Earth, resulting in the amount of observable reflected light	1
E.ST.05.23	Recognize that nighttime objects (stars and constellations) and the sun appear to move because the Earth rotates on its axis and orbits the sun.	1
E.ST.05.24	Explain lunar and solar eclipses based on the relative positions of the Earth, moon, and sun, and the orbit of the moon.	1
E.ST.05.25	Explain the tides of the oceans as they relate to the gravitational pull and orbit of the moon	1

Sixth Grade Science Alignment Record Science GLCE v.12.07

MICHIGAN Department of Education

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.M.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S.IP.06.11	Generate scientific questions based on observations, investigations, and research.	2
S.IP.06.12	Design and conduct scientific investigations	3
S.IP.06.13	Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens, thermometer, models, sieves, microscopes) appropriate to scientific investigations	1
S.IP.06.14	Use metric measurement devices in an investigation	1
S.IP.06.15	Construct charts and graphs from data and observations.	2
S.IP.06.16	Identify patterns in data.	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.M.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations.	
S.IA.06.11	Analyze information from data tables and graphs to answer scientific questions.	2
S.IA.06.12	Evaluate data, claims, and personal knowledge through collaborative science discourse	2
S.IA.06.13	Communicate and defend findings of observations and investigations using evidence	3
S.IA.06.14	Draw conclusions from sets of data from multiple trials of a scientific investigation.	3
S.IA.06.15	Use multiple sources of information to evaluate strengths and weaknesses of claims, arguments, or data	3
Science Processes	**Reflection and Social Implications**	
Statement S.RS.M.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision-making and the application of science throughout history and within society.	
S.RS.06.11	Evaluate the strengths and weaknesses of claims, arguments, and data.	3
S.RS.06.12	Describe limitations in personal and scientific knowledge	2
S.RS.06.13	Identify the need for evidence in making scientific decisions	1
S.RS.06.14	Evaluate scientific explanations based on current evidence and scientific principles	3
S.RS.06.15	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S.RS.06.16	Design solutions to problems using technology.	3

GLCE Code	Expectation	DOK
S.RS.06.17	Describe the effect humans and other organisms have on the balance of the natural world.	1
S.RS.06.18	Describe what science and technology can and cannot reasonably contribute to society.	1
S.RS.06.19	Describe how science and technology have advanced because of the contributions of many people throughout history and across cultures.	1
Physical Science	**Energy**	
Statement P.EN.M.1	Kinetic and Potential Energy- Objects and substances in motion have kinetic energy. Objects and substances may have potential energy due to their relative positions in a system. Gravitational, elastic, and chemical energy are all forms of potential energy.	
P.EN.06.11	Identify kinetic or potential energy in everyday situations (for example: stretched rubber band, objects in motion, ball on a hill, food energy).	1
P.EN.06.12	Demonstrate the transformation between potential and kinetic energy in simple mechanical systems (for example: roller coasters, pendulums).	1
Statement P.EN.M.4	Energy Transfer- Energy is transferred from a source to a receiver by radiation, conduction, and convection. When energy is transferred from a source to a receiver, the quantity of energy before the transfer is equal to the quantity of energy after the transfer.	
P.EN.06.41	Explain how different forms of energy can be transferred from one place to another by radiation, conduction, or convection	1
P.EN.06.42	Illustrate how energy can be transferred while no energy is lost or gained in the transfer	1
Physical Science	**Changes in Matter**	
Statement P.CM.M.1	Changes in State- Matter changing from state to state can be explained by using models which show that matter is composed of tiny particles in motion. When changes of state occur, the atoms and/or molecules are not changed in structure. When the changes in state occur, mass is conserved because matter is not created or destroyed.	
P.CM.06.11	Describe and illustrate changes in state, in terms of the arrangement and relative motion of the atoms or molecules.	1
P.CM.06.12	Explain how mass is conserved as it changes from state to state in a closed system.	1
Life Science	**Organization of Living Things**	
Statement L.OL.M.5	Producers, Consumers, and Decomposers- All animals, including humans, are consumers that meet their energy by eating other organisms or their products. Consumers break down the structures of the organisms they eat to make the materials they need to grow and function. Decomposers, including bacteria and fungi, use dead organisms or their products to meet their energy needs.	
L.OL.06.51	Classify organisms (producers, consumers, and decomposers) based on their source of energy for growth and development.	2
L.OL.06.52	Distinguish between the ways in which consumers and decomposers obtain energy.	1

GLCE Code	Expectation	DOK
Life Science	**Ecosystems**	
Statement L.EC.M.1	Interactions of Organisms- Organisms of one species form a population. Populations of different organisms interact and form communities. Living communities and nonliving factors that interact with them form ecosystems.	
L.EC.06.11	List examples of populations, communities, and ecosystems including the Great Lakes region.	1
Statement L.EC.M.2	Relationships of Organisms- Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/ prey, or parasite/host relationship. Some organisms may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.	
L.EC.06.21	Describe common patterns of relationships between and among populations (competition, parasitism, symbiosis, predator/prey).	1
L.EC.06.22	Explain how two populations of organisms can be mutually beneficial and how that can lead to interdependency	2
L.EC.06.23	Predict how changes in one population might affect other populations based upon their relationships in the food web	2
Statement L.EC.M.3	Biotic and Abiotic Factors- The number of organisms and populations an ecosystem can support depends on the biotic (living) resources available and abiotic (nonliving) factors, such as quality of light and water, range of temperatures and soil composition.	
L.EC.06.31	Identify the living (biotic) and nonliving (abiotic) components of an ecosystem.	1
L.EC.06.32	Identify the factors in an ecosystem that influence changes in population size.	1
Statement L.EC.M.4	Environmental Impact of Organisms- All organisms (including humans) cause change in the environment where they live. Some of the changes are harmful to the organism or other organisms, whereas others are helpful	
L.EC.06.41	Describe how human beings are part of the ecosystem of the Earth and that human activity can purposefully, or accidentally, alter the balance in ecosystems.	1
L.EC.06.42	Predict possible consequences of overpopulation of organisms, including humans, (for example: species extinction, resource depletion, climate change, pollution)	1
Earth Science	**Solid Earth**	
Statement E.SE.M.1	Soil- Soils consist of weathered rocks and decomposed organic materials from dead plants, animals, and bacteria. Soils are often found in layers with each having a different chemical composition and texture.	
E.SE.06.11	Explain how physical and chemical weathering lead to erosion and the formation of soils and sediments	1
E.SE.06.12	Explain how waves, wind, water, and glacier movement, shape and reshape the land surface of the Earth by eroding rock in some areas and depositing sediments in other areas.	1
E.SE.06.13	Describe how soil is a mixture, made up of weather eroded rock and decomposed organic material	1
E.SE.06.14	Compare different soil samples based on particle size and texture	2
Statement E.SE.M.4	Rock Formation- Rocks and rock formations bear evidence of the minerals, materials, temperature/pressure conditions, and forces that created them.	
E.SE.06.41	Compare and contrast the formation of rock types (igneous, metamorphic, and sedimentary) and demonstrate the similarities and differences using the rock cycle model.	2

GLCE Code	Expectation	DOK
Statement E.SE.M.5	Plate Tectonics- The lithospheric plates of the Earth constantly move, resulting in major geological events, such as earthquakes, volcanic eruptions, and mountain building.	
E.SE.06.51	Explain plate tectonic movement and how the lithospheric plates move centimeters each year.	1
E.SE.06.52	Demonstrate how major geological events (earthquakes, volcanic eruptions, mountain building) result from these plate motions	1
E.SE.06.53	Describe layers of the Earth as a lithosphere (crust and upper mantle), convecting mantle, and dense metallic core	1
Statement E.SE.M.6	Magnetic Field of Earth- Earth as a whole has a magnetic field that is detectable at the surface with a compass	
E.SE.06.61	Describe the Earth as a magnet and compare the magnetic properties of the Earth to that of a natural or man-made magnet	2
E.SE.06.62	Explain how a compass works using the magnetic field of the Earth, and how a compass is used for navigation on land and sea.	1
Earth Science	**Earth in Space and Time**	
Statement E.ST.M.3	M.3 Fossils- Fossils provide important evidence of how life and environmental conditions have changed in a given location	
E.ST.06.31	Explain how rocks and fossils are used to understand the age and geological history of the earth (timelines and relative dating, rock layers)	1
Statement E.ST.M.4	Geologic Time- Earth processes seen today (erosion, mountain building, and glacier movement) make possible the measurement of geologic time through methods such as observing rock sequences and using fossils to correlate the sequences at various locations.	
E.ST.06.41	Explain how Earth processes (erosion, mountain building, and glacier movement) are used for the measurement of geologic time through observing rock layers.	1
E.ST.06.42	Describe how fossils provide important evidence of how life and environmental conditions have changed	1

Seventh Grade Science Alignment Record Science GLCE v.12.07

MICHIGAN Department of Education

GLCE Code	Expectation	DOK
Science Processes	**Inquiry Process**	
Statement S.IP.M.1	Inquiry involves generating questions, conducting investigations, and developing solutions to problems through reasoning and observation	
S.IP.07.11	Generate scientific questions based on observations, investigations, and research.	2
S.IP.07.12	Design and conduct scientific investigations.	3
S.IP.07.13	Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens, thermometer, models, sieves, microscopes, hot plates, pH meters) appropriate to scientific investigations	1
S.IP.07.14	Use metric measurement devices in an investigation	1
S.IP.07.15	Construct charts and graphs from data and observations.	2
S.IP.07.16	Identify patterns in data	2
Science Processes	**Inquiry Analysis and Communication**	
Statement S.IA.M.1	Inquiry includes an analysis and presentation of findings that lead to future questions, research, and investigations.	
S.IA.07.11	Analyze information from data tables and graphs to answer scientific questions	2
S.IA.07.12	Evaluate data, claims, and personal knowledge through collaborative science discourse.	2
S.IA.07.13	Communicate and defend findings of observations and investigations.	3
S.IA.07.14	Draw conclusions from sets of data from multiple trials of a scientific investigation to draw conclusions	3
S.IA.07.15	Use multiple sources of information to evaluate strengths and weaknesses of claims, arguments, or data	3
Science Processes	**Reflection and Social Implications**	
Statement S.RS.M.1	Reflecting on knowledge is the application of scientific knowledge to new and different situations. Reflecting on knowledge requires careful analysis of evidence that guides decision-making and the application of science throughout history and within society.	
S.RS.07.11	Evaluate the strengths and weaknesses of claims, arguments, and data	3
S.RS.07.12	Describe limitations in personal and scientific knowledge.	2
S.RS.07.13	Identify the need for evidence in making scientific decisions.	1
S.RS.07.14	Evaluate scientific explanations based on current evidence and scientific principles.	3
S.RS.07.15	Demonstrate scientific concepts through various illustrations, performances, models, exhibits, and activities.	1
S.RS.07.16	Design solutions to problems using technology.	3

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S.RS.07.17	Describe the effect humans and other organisms have on the balance of the natural world.	1
S.RS.07.18	Describe what science and technology can and cannot reasonably contribute to society	1
S.RS.07.19	Describe how science and technology have advanced because of the contributions of many people throughout history and across cultures	1
Physical Science	**Energy**	
Statement P.EN.M.3	Waves and Energy-Waves have energy and transfer energy when they interact with matter. Examples of waves include sound waves, seismic waves, waves on water, and light waves.	
P.EN.07.31	Identify examples of waves, including sound waves, seismic waves, and waves on water.	1
P.EN.07.32	Describe how waves are produced by vibrations in matter.	1
P.EN.07.33	Demonstrate how waves transfer energy when they interact with matter (for example: tuning fork in water, waves hitting a beach, earthquake knocking over buildings).	1
Statement P.EN.M.4	Energy Transfer- Energy is transferred from a source to a receiver by radiation, conduction, and convection. When energy is transferred from a source to a receiver, the quantity of energy before the transfer is equal to the quantity of energy after the transfer.	
P.EN.07.43	Explain how light energy is transferred to chemical energy through the process of photosynthesis	1
Statement P.EN.M.6	Solar Energy Effects- Nuclear reactions take place in the sun producing heat and light. Only a tiny fraction of the light energy from the sun reaches Earth, providing energy to heat the Earth	
P.EN.07.61	Identify that nuclear reactions take place in the sun, producing heat and light.	1
P.EN.07.62	Explain how only a tiny fraction of light energy from the sun is transformed to heat energy on Earth.	1
Physical Science	**Properties of Matter**	
Statement P.PM.M.1	Chemical Properties- Matter has chemical properties. The understanding of chemical properties helps to explain how new substances are formed	
P.PM.07.11	Classify substances by their chemical properties (flammability, pH, acid-base indicators, reactivity)	2
Statement P.PM.M.2	Elements and Compounds- Elements are composed of a single kind of atom that are grouped into families with similar properties on the periodic table. Compounds are composed of two or more different elements. Each element and compound has a unique set of physical and chemical properties such as boiling point, density, color, conductivity, and reactivity.	
P.PM.07.21	Identify the smallest component that makes up an element	1
P.PM.07.22	Describe how the elements within the Periodic Table are organized by similar properties into families (highly reactive metals, less reactive metals, highly reactive nonmetals, and some almost completely non-reactive gases)	1
P.PM.07.23	Illustrate the structure of molecules using models or drawings (water, carbon dioxide, salt).	1
P.PM.07.24	List examples of physical and chemical properties of elements and compounds (boiling point, density, color, conductivity, reactivity)	1

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Physical Science	**Changes in Matter**	
Statement P.CM.M.2	Chemical Changes- Chemical changes occur when two elements and/or compounds react and produce new substances. These new substances have different physical and chemical properties than the original elements and/or compounds. During the chemical change, the number and kind of atoms in the reactants are the same as the number and kind of atoms in the products. Mass is conserved during chemical changes. The mass of the reactants is the same as the mass of the products.	
P.CM.07.21	Identify evidence of chemical change through color, gas formation, solid formation, and temperature change.	1
P.CM.07.22	Compare and contrast the chemical properties of a new substance with the original after a chemical change.	2
P.CM.07.23	Describe the physical properties and chemical properties of the products and reactants in a chemical change.	1
Life Science	**Organization of Living Things**	
Statement L.OL.M.2	Cell Functions- All organisms are composed of cells, from one cell to many cells. In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells, and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms.	
L.OL.07.21	Recognize that all organisms are composed of cells (single cell organisms, multicellular organisms).	1
L.OL.07.22	Explain how cells make up different body tissues, organs, and organ systems.	1
L.OL.07.23	Describe how cells in all multicellular organisms are specialized to take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or organism needs.	1
L.OL.07.24	Recognize that cells function in a similar way in all organisms	1
Statement L.OL.M.3	Growth and Development- Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissue of an embryo.	
L.OL.07.31	Describe growth and development in terms of increase of cell number and/or cell size.	1
L.OL.07.32	Examine how through cell division, cells can become specialized for specific functions.	1
Statement L.OL.M.6	Photosynthesis- Plants are producers; they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars along with minerals from the soil to form fats, proteins, and carbohydrates. These products can be used immediately, incorporated into the cells of a plant as the plant grows, or stored for later use.	
L.OL.07.61	Recognize the need for light to provide energy for the production of carbohydrates, proteins and fats	1
L.OL.07.62	Explain that carbon dioxide and water are used to produce carbohydrates, proteins, and fats.	1
L.OL.07.63	Describe evidence that plants make, use and store food	1
Life Science	**Heredity**	
Statement L.HE.M.2	Reproduction- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually	
L.HE.07.21	Compare how characteristics of living things are passed on through generations, both asexually and sexually.	2
L.HE.07.22	Compare and contrast the advantages and disadvantages of sexual vs asexual reproduction.	2

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Earth Science	**Earth Systems**	
Statement E.ES.M.1	Solar Energy- The sun is the major source of energy for phenomena on the surface of the Earth.	
E.ES.07.11	Demonstrate, using a model or drawing, the relationship between the warming by the sun of the Earth and the water cycle as it applies to the atmosphere (evaporation, water vapor, warm air rising, cooling, condensation, clouds).	1
E.ES.07.12	Describe the relationship between the warming of the atmosphere of the Earth by the sun and convection within the atmosphere and oceans	1
E.ES.07.13	Describe how the warming of the Earth by the sun produces winds and ocean currents	1
Statement E.ES.M.4	Human Consequences- Human activities have changed the land, oceans, and atmosphere of the Earth resulting in the reduction of the number and variety of wild plants and animals sometimes causing extinction of species.	
E.ES.07.41	Explain how human activities (surface mining, deforestation, overpopulation, construction and urban development, farming, dams, landfills, and restoring natural areas) change the surface of the Earth and affect the survival of organisms	2
E.ES.07.42	Describe the origins of pollution in the atmosphere, geosphere, and hydrosphere, (car exhaust, industrial emissions, acid rain, and natural sources), and how pollution impacts habitats, climatic change, threatens or endangers species.	2
Statement E.ES.M.7	Weather and Climate- Global patterns of atmospheric and oceanic movement influence weather and climate	
E.ES.07.71	Compare and contrast the difference and relationship between climate and weather.	2
E.ES.07.72	Describe how different weather occurs due to the constant motion of the atmosphere from the energy of the sun reaching the surface of the Earth	1
E.ES.07.73	Explain how the temperature of the oceans affects the different climates on Earth because water in the oceans holds a large amount of heat.	1
E.ES.07.74	Describe weather conditions associated with frontal boundaries (cold, warm, stationary, and occluded) and the movement of major air masses and the jet stream across North America using a weather map	1
Statement E.ES.M.8	Water Cycle- Water circulates through the four spheres of the Earth in what is known as the "water cycle."	
E.ES.07.81	Explain the water cycle and describe how evaporation, transpiration, condensation, cloud formation, precipitation, infiltration, surface runoff, ground water, and absorption occur within the cycle	1
E.ES.07.82	Analyze the flow of water between the components of a watershed, including surface features (lakes, streams, rivers, wetlands) and groundwater	2
Earth Science	**Fluid Earth**	
Statement E.FE.M.1	Atmosphere- The atmosphere is a mixture of nitrogen, oxygen and trace gases that include water vapor. The atmosphere has different physical and chemical composition at different elevations.	
E.FE.07.11	Describe the atmosphere as a mixture of gases	1
E.FE.07.12	Compare and contrast the composition of the atmosphere at different elevations	2

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Standard B1	**INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS**	
Statement B1.1	**Scientific Inquiry** Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	
B1.1A	Generate new questions that can be investigated in the laboratory or field	3
B1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	3
B1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	2
B1.1D	Identify patterns in data and relate them to theoretical models.	2
B1.1E	Describe a reason for a given conclusion using evidence from an investigation.	3
B1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.	3
B1.1g	Use empirical evidence to explain and critique the reasoning used to draw a scientific conclusion or explanation.	3
B1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	3
B1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	2
Statement B1.2	**Scientific Reflection and Social Implications** The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	
B1.2A	Critique whether or not specific questions can be answered through scientific investigations.	3
B1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence.	3
B1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	3
B1.2D	Evaluate scientific explanations in a peer review process or discussion format.	3
B1.2E	Evaluate the future career and occupational prospects of science fields	2
B1.2f	Critique solutions to problems, given criteria and scientific constraints	3
B1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions.	2
B1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.	2
B1.2i	Explain the progression of ideas and explanations that leads to science theories that are part of the current scientific consensus or core knowledge.	2
B1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions.	3
B1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	2

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Standard B2	**ORGANIZATION AND DEVELOPMENT OF LIVING SYSTEMS**	
Statement L2.p1	**Cells *(prerequisite)*** All organisms are composed of cells, from just one cell to many cells Water accounts for more than two-thirds of the weight of a cell, which gives cells many of their properties In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of organisms for food, air, and waste removal. The way in which cells function is similar in all living organisms *(prerequisite)*	
L2.p1A	Distinguish between living and nonliving systems. *(prerequisite)*	P
L2.p1B	Explain the importance of both water and the element carbon to cells. *(prerequisite)*	P
L2.p1C	Describe growth and development in terms of increase in cell number, cell size, and/or cell products *(prerequisite)*	P
L2.p1d	Explain how the systems in a multicellular organism work together to support the organism. *(prerequisite)*	P
L2.p1E	Compare and contrast how different organisms accomplish similar functions (e.g., obtain oxygen for respiration, and excrete waste). *(prerequisite)*	P
Statement L2.p2	**Cell Function *(prerequisite)*** Cells carry out the many functions needed to sustain life They grow and divide, thereby producing more cells Food is used to provide energy for the work that cells do and is a source of the molecular building blocks from which needed materials are assembled. *(prerequisite)*	
L2.p2A	Describe how organisms sustain life by obtaining, transporting, transforming, releasing, and eliminating matter and energy. *(prerequisite)*	P
L2.p2B	Describe the effect of limiting food to developing cells. *(prerequisite)*	P
Statement L2.p3	**Plants as Producers (prerequisite)** Plants are producers; they use the energy from light to make sugar molecules from the atoms of carbon dioxide and water. Plants use these sugars, along with minerals from the soil, to form fats, proteins, and carbohydrates. This food can be used immediately, incorporated into the cells of a plant as the plant grows, or stored for later use. *(prerequisite)*	
L2.p3A	Explain the significance of carbon in organic molecules. *(prerequisite)*	P
L2.p3B	Explain the origins of plant mass. *(prerequisite)*	P
L2.p3C	Predict what would happen to plants growing in low carbon dioxide atmospheres. *(prerequisite)*	P
L2.p3D	Explain how the roots of specific plants grow. *(prerequisite)*	P
Statement L2.p4	**Animals as Consumers *(prerequisite)*** All animals, including humans, are consumers: they obtain food by eating other organisms or their products. Consumers break down the structures of the organisms they eat to obtain the materials they need to grow and function. Decomposers, including bacteria and fungi, use dead organisms or their products for food *(prerequisite)*	
L2.p4A	Classify different organisms based on how they obtain energy for growth and development. *(prerequisite)*	P
L2.p4B	Explain how an organism obtains energy from the food it consumes. *(prerequisite)*	P
Statement L2.p5	**Common Elements *(prerequisite)*** Living systems are made of complex molecules that consist mostly of a few elements, especially carbon, hydrogen, oxygen, nitrogen, and phosphorous. *(prerequisite)*	
L2.p5A	Recognize the six most common elements in organic molecules (C, H, N, O, P, S). *(prerequisite)*	P
L2.p5B	Identify the most common complex molecules that make up living organisms. *(prerequisite)*	P
L2.p5C	Predict what would happen if essential elements were withheld from developing cells. *(prerequisite)*	P
Statement B2.1	**Transformation of Matter and Energy in Cells** In multicellular organisms, cells are specialized to carry out specific functions such as transport, reproduction, or energy transformation.	
B2.1A	Explain how cells transform energy (ultimately obtained from the sun) from one form to another through the processes of photosynthesis and respiration. Identify the reactants and products in the general reaction of photosynthesis.	2
B2.1B	Compare and contrast the transformation of matter and energy during photosynthesis and respiration.	2
B2.1C	Explain cell division, growth, and development as a consequence of an increase in cell number, cell size, and/or cell products.	2
Statement B2.1x	**Cell Differentiation** Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and	

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	function to form the basic tissues of an embryo.	
B2.1d	Describe how, through cell division, cells can become specialized for specific function.	1
B2 1e	Predict what would happen if the cells from one part of a developing embryo were transplanted to another part of the embryo.	2
Statement B2.2	**Organic Molecules** There are four major categories of organic molecules that make up living systems: carbohydrates, fats, proteins, and nucleic acids.	
B2.2A	Explain how carbon can join to other carbon atoms in chains and rings to form large and complex molecules.	1
B2.2B	Recognize the six most common elements in organic molecules (C, H, N, O, P, S).	1
B2.2C	Describe the composition of the four major categories of organic molecules (carbohydrates, lipids, proteins, and nucleic acids).	1
B2.2D	Explain the general structure and primary functions of the major complex organic molecules that compose living organisms.	1
B2.2E	Describe how dehydration and hydrolysis relate to organic molecules.	2
Statement B2.2x	**Proteins** Protein molecules are long, usually folded chains composed mostly of amino acids and are made of C, H, O, and N. Protein molecules assemble fats and carbohydrates; they function as enzymes, structural components, and hormones. The function of each protein molecule depends on its specific sequence of amino acids and the shape of the molecule.	
B2.2f	Explain the role of enzymes and other proteins in biochemical functions (e.g., the protein hemoglobin carries oxygen in some organisms, digestive enzymes, and hormones).	1
B2.2g	Propose how moving an organism to a new environment may influence its ability to survive and predict the possible impact of this type of transfer.	3
Statement B2.3	**Maintaining Environmental Stability** The internal environment of living things must remain relatively constant. Many systems work together to maintain stability. Stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.	
B2.3A	Describe how cells function in a narrow range of physical conditions, such as temperature and pH (acidity), to perform life functions.	1
B2.3B	Describe how the maintenance of a relatively stable internal environment is required for the continuation of life.	1
B2.3C	Explain how stability is challenged by changing physical, chemical, and environmental conditions as well as the presence of disease agents.	2
Statement B2.3x	**Homeostasis** The internal environment of living things must remain relatively constant. Many systems work together to maintain homeostasis. When homeostasis is lost, death occurs.	
B2.3d	Identify the general functions of the major systems of the human body (digestion, respiration, reproduction, circulation, excretion, protection from disease, and movement, control, and coordination) and describe ways that these systems interact with each other.	2
B2.3e	Describe how human body systems maintain relatively constant internal conditions (temperature, acidity, and blood sugar).	1
B2.3f	Explain how human organ systems help maintain human health.	2
B2.3g	Compare the structure and function of a human body system or subsystem to a nonliving system (e.g., human joints to hinges, enzyme and substrate to interlocking puzzle pieces).	2
Statement B2.4	**Cell Specialization** In multicellular organisms, specialized cells perform specialized functions. Organs and organ systems are composed of cells and function to serve the needs of cells for food, air, and waste removal. The way in which cells function is similar in all living organisms.	
B2.4A	Explain that living things can be classified based on structural, embryological, and molecular (relatedness of DNA sequence) evidence.	1
B2.4B	Describe how various organisms have developed different specializations to accomplish a particular function and yet the end result is the same (e.g., excreting nitrogenous wastes in animals, obtaining oxygen for respiration).	2
B2.4C	Explain how different organisms accomplish the same result using different structural specializations (gills vs lungs vs. membranes).	2
B2.4d	Analyze the relationships among organisms based on their shared physical, biochemical, genetic, and cellular characteristics and functional processes.	2

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B2.4e	Explain how cellular respiration is important for the production of ATP (build on aerobic vs. anaerobic).	2
B2.4f	Recognize and describe that both living and nonliving things are composed of compounds, which are themselves made up of elements joined by energy containing bonds, such as those in ATP.	1
B2.4g	Explain that some structures in the modern eukaryotic cell developed from early prokaryotes, such as mitochondria, and in plants, chloroplasts.	1
B2.4h	Describe the structures of viruses and bacteria.	1
B2.4i	Recognize that while viruses lack cellular structure, they have the genetic material to invade living cells.	1
Statement B2.5	**Living Organism Composition** All living or once-living organisms are composed of carbohydrates, lipids, proteins, and nucleic acids. Carbohydrates and lipids contain many carbon-hydrogen bonds that also store energy.	
B2.5A	Recognize and explain that macromolecules such as lipids contain high energy bonds.	1
B2.5B	Explain how major systems and processes work together in animals and plants, including relationships between organelles, cells, tissues, organs, organ systems, and organisms. Relate these to molecular functions.	2
B2.5C	Describe how energy is transferred and transformed from the Sun to energy-rich molecules during photosynthesis.	2
B2.5D	Describe how individual cells break down energy-rich molecules to provide energy for cell functions.	1
Statement B2.5x	**Energy Transfer** All living or once-living organisms are composed of carbohydrates, lipids, proteins, and nucleic acids Carbohydrates and lipids contain many carbon-hydrogen bonds that also store energy However, that energy must be transferred to ATP (adenosine triphosphate) to be usable by the cell.	
B2.5e	Explain the interrelated nature of photosynthesis and cellular respiration in terms of ATP synthesis and degradation.	2
B2.5f	Relate plant structures and functions to the process of photosynthesis and respiration.	2
B2.5g	Compare and contrast plant and animal cells.	2
B2.5h	Explain the role of cell membranes as a highly selective barrier (diffusion, osmosis, and active transport)	1
B2.5i	Relate cell parts/organelles to their function.	1
Statement B2.6x	**Internal/External Cell Regulation** Cellular processes are regulated both internally and externally by environments in which cells exist, including local environments that lead to cell differentiation during the development of multicellular organisms. During the development of complex multicellular organisms, cell differentiation is regulated through the expression of different genes.	
B2.6a	Explain that the regulatory and behavioral responses of an organism to external stimuli occur in order to maintain both short- and long-term equilibrium.	2
B2.r6b	Explain that complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division Note that cell behavior can also be affected by molecules from other parts of the organism, such as hormones. *(recommended)*	R
B2.r6c	Recognize and explain that communication and/or interaction are required between cells to coordinate their diverse activities. *(recommended)*	R
B2.r6d	Explain how higher levels of organization result from specific complex interactions of smaller units and that their maintenance requires a constant input of energy as well as new material. *(recommended)*	R
B2.r6e	Analyze the body's response to medical interventions such as organ transplants, medicines, and inoculations. *(recommended)*	R
Standard B3	**INTERDEPENDENCE OF LIVING SYSTEMS AND THE ENVIRONMENT**	
Statement L3.p1	**Populations, Communities, and Ecosystems *(prerequisite)*** Organisms of one species form a population. Populations of different organisms interact and form communities. Living communities and the nonliving factors that interact with them form ecosystems. *(prerequisite)*	
L3.p1A	Provide examples of a population, community, and ecosystem. *(prerequisite)*	P
Statement L3.p2	**L3.p2 Relationships Among Organisms *(prerequisite)*** Two types of organisms may interact with one another in several ways; they may be in a producer/consumer,	

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	predator/ prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other. *(prerequisite)*	
L3.p2A	Describe common relationships among organisms and provide examples of producer/consumer, predator/ prey, or parasite/host relationship. *(prerequisite)*	P
L3.p2B	Describe common ecological relationships between and among species and their environments (competition, territory, carrying capacity, natural balance, population, dependence, survival, and other biotic and abiotic factors). *(prerequisite)*	P
L3.p2C	Describe the role of decomposers in the transfer of energy in an ecosystem *(prerequisite)*	P
L3.p2D	Explain how two organisms can be mutually beneficial and how that can lead to interdependency. *(prerequisite)*	P
Statement L3.p3	**Factors Influencing Ecosystems *(prerequisite)*** The number of organisms and populations an ecosystem can support depends on the biotic resources available and abiotic factors, such as quantity of light and water, range of temperatures, and soil composition. *(prerequisite)*	
L3.p3A	Identify the factors in an ecosystem that influence fluctuations in population size. *(prerequisite)*	P
L3.p3B	Distinguish between the living (biotic) and nonliving (abiotic) components of an ecosystem. *(prerequisite)*	P
L3.p3C	Explain how biotic and abiotic factors cycle in an ecosystem (water, carbon, oxygen, and nitrogen). *(prerequisite)*	P
L3.p3D	Predict how changes in one population might affect other populations based upon their relationships in a food web. *(prerequisite)*	P
Statement L3.p4	**Human Impact on Ecosystems *(prerequisite)*** All organisms cause changes in their environments. Some of these changes are detrimental, whereas others are beneficial. *(prerequisite)*	
L3.p4A	Recognize that, and describe how, human beings are part of Earth's ecosystems. Note that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. *(prerequisite)*	P
Statement B3.1	**Photosynthesis and Respiration** Organisms acquire their energy directly or indirectly from sunlight. Plants capture the Sun's energy and use it to convert carbon dioxide and water to sugar and oxygen through the process of photosynthesis. Through the process of cellular respiration, animals are able to release the energy stored in the molecules produced by plants and use it for cellular processes, producing carbon dioxide and water.	
B3.1A	Describe how organisms acquire energy directly or indirectly from sunlight	1
B3.1B	Illustrate and describe the energy conversions that occur during photosynthesis and respiration.	2
B3.1C	Recognize the equations for photosynthesis and respiration and identify the reactants and products for both.	1
B3.1D	Explain how living organisms gain and use mass through the processes of photosynthesis and respiration.	2
B3.1e	Write the chemical equation for photosynthesis and cellular respiration and explain in words what they mean	1
B3.1f	Summarize the process of photosynthesis	2
Statement B3.2	**Ecosystems** The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in an ecosystem, some energy is stored in newly made structures, but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.	
B3.2A	Identify how energy is stored in an ecosystem.	1

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B3.2B	Describe energy transfer through an ecosystem, accounting for energy lost to the environment as heat.	2
B3.2C	Draw the flow of energy through an ecosystem. Predict changes in the food web when one or more organisms are removed.	2
Statement B3.3	**Element Recombination** As matter cycles and energy flows through different levels of organization of living systems—cells, organs, organisms, and communities—and between living systems and the physical environment, chemical elements are recombined in different ways. Each recombination results in storage and dissipation of energy into the environment as heat. Matter and energy are conserved in each change.	
B3.3A	Use a food web to identify and distinguish producers, consumers, and decomposers and explain the transfer of energy through trophic levels.	2
B3.3b	Describe environmental processes (e.g., the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life.	2
Statement B3.4	**Changes in Ecosystems** Although the interrelationships and interdependence of organisms may generate biological communities in ecosystems that are stable for hundreds or thousands of years, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. The impact of the human species has major consequences for other species.	
B3.4A	Describe ecosystem stability. Understand that if a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages of succession that eventually result in a system similar to the original one.	1
B3.4B	Recognize and describe that a great diversity of species increases the chance that at least some living organisms will survive in the face of cataclysmic changes in the environment.	2
B3.4C	Examine the negative impact of human activities.	2
Statement B3.4x	**Human Impact** Humans can have tremendous impact on the environment. Sometimes their impact is beneficial, and sometimes it is detrimental.	
B3.4d	Describe the greenhouse effect and list possible causes	1
B3.4e	List the possible causes and consequences of global warming	1
Statement B3.5	**Populations** Populations of living things increase and decrease in size as they interact with other populations and with the environment. The rate of change is dependent upon relative birth and death rates.	
B3.5A	Graph changes in population growth, given a data table	2
B3.5B	Explain the influences that affect population growth.	2
B3.5C	Predict the consequences of an invading organism on the survival of other organisms	2
Statement B3.5x	**Environmental Factors** The shape of population growth curves vary with the type of organism and environmental conditions, such as availability of nutrients and space. As the population increases and resources become more scarce, the population usually stabilizes at the carrying capacity of that environment.	
B3.5d	Describe different reproductive strategies employed by various organisms and explain their advantages and disadvantages.	2
B3.5e	Recognize that and describe how the physical or chemical environment may influence the rate, extent, and nature of population dynamics within ecosystems.	2
B3.5f	Graph an example of exponential growth. Then show the population leveling off at the carrying capacity of the environment.	2
B3.5g	Diagram and describe the stages of the life cycle for a human disease-causing organism *(recommended)*	1 R - ?

HSCE Code	Expectation	DOK
Standard B4	**GENETICS**	
L4.p1	**Reproduction *(prerequisite)*** Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually. *(prerequisite)*	
L4.p1A	Compare and contrast the differences between sexual and asexual reproduction. *(prerequisite)*	P
L4.p1B	Discuss the advantages and disadvantages of sexual vs. asexual reproduction *(prerequisite)*	P
Statement L4.p2	**Heredity and Environment (prerequisite)** The characteristics of organisms are influenced by heredity and environment. For some characteristics, inheritance is more important. For other characteristics, interactions with the environment are more important. *(prerequisite)*	
L4.p2A	Explain that the traits of an individual are influenced by both the environment and the genetics of the individual. Acquired traits are not inherited; only genetic traits are inherited. *(prerequisite)*	P
Statement B4.1	**Genetics and Inherited Traits** Hereditary information is contained in genes, located in the chromosomes of each cell. Cells contain many thousands of different genes. One or many genes can determine an inherited trait of an individual, and a single gene can influence more than one trait. Before a cell divides, this genetic information must be copied and apportioned evenly into the daughter cells.	
B4.1A	Draw and label a homologous chromosome pair with heterozygous alleles highlighting a particular gene location.	1
B4.1B	Explain that the information passed from parents to offspring is transmitted by means of genes that are coded in DNA molecules. These genes contain the information for the production of proteins.	1
B4.1c	Differentiate between dominant, recessive, codominant, polygenic, and sex-linked traits.	2
B4.1d	Explain the genetic basis for Mendel's laws of segregation and independent assortment	1
B4.1e	Determine the genotype and phenotype of monohybrid crosses using a Punnett Square	2
Statement B4.2	**DNA** The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.	
B4.2A	Show that when mutations occur in sex cells, they can be passed on to offspring (inherited mutations), but if they occur in other cells, they can be passed on to descendant cells only (noninherited mutations).	1
B4.2B	Recognize that every species has its own characteristic DNA sequence	1
B4.2C	Describe the structure and function of DNA.	1
B4.2D	Predict the consequences that changes in the DNA composition of particular genes may have on an organism (e.g., sickle cell anemia, other).	2
B4.2E	Propose possible effects (on the genes) of exposing an organism to radiation and toxic chemicals	2
Statement B4.2x	**DNA, RNA, and Protein Synthesis** Protein synthesis begins with the information in a sequence of DNA bases being copied onto messenger RNA. This molecule moves from the nucleus to the ribosome in the cytoplasm where it is "read." Transfer RNA brings amino acids to the ribosome, where they are connected in the correct sequence to form a specific protein.	
B4.2f	Demonstrate how the genetic information in DNA molecules provides instructions for assembling protein molecules and that this is virtually the same mechanism for all life forms.	2
B4.2g	Describe the processes of replication, transcription, and translation and how they relate to each other in molecular biology.	2

HSCE Code	Expectation	DOK
B4.2h	Recognize that genetic engineering techniques provide great potential and responsibilities.	1
B4.2i	Explain how recombinant DNA technology allows scientists to analyze the structure and function of genes. *(recommended)*	1 R -?
Statement B4.3	**Cell Division — Mitosis and Meiosis** Sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations from the offspring of any two parents.	
B4.3A	Compare and contrast the processes of cell division (mitosis and meiosis), particularly as those processes relate to production of new cells and to passing on genetic information between generations.	2
B4.3B	Explain why only mutations occurring in gametes (sex cells) can be passed on to offspring.	1
B4.3C	Explain how it might be possible to identify genetic defects from just a karyotype of a few cells.	2
B4.3d	Explain that the sorting and recombination of genes in sexual reproduction result in a great variety of possible gene combinations from the offspring of two parents.	1
B4.3e	Recognize that genetic variation can occur from such processes as crossing over, jumping genes, and deletion and duplication of genes.	1
B4.3f	Predict how mutations may be transferred to progeny.	2
B4.3g	Explain that cellular differentiation results from gene expression and/or environmental influence (e.g., metamorphosis, nutrition).	2
Statement B4.4x	**Genetic Variation** Genetic variation is essential to biodiversity and the stability of a population. Genetic variation is ensured by the formation of gametes and their combination to form a zygote. Opportunities for genetic variation also occur during cell division when chromosomes exchange genetic material causing permanent changes in the DNA sequences of the chromosomes. Random mutations in DNA structure caused by the environment are another source of genetic variation.	
B4.4a	Describe how inserting, deleting, or substituting DNA segments can alter a gene. Recognize that an altered gene may be passed on to every cell that develops from it and that the resulting features may help, harm, or have little or no effect on the offspring's success in its environment.	2
B4.4b	Explain that gene mutation in a cell can result in uncontrolled cell division called cancer. Also know that exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.	1
B4.4c	Explain how mutations in the DNA sequence of a gene may be silent or result in phenotypic change in an organism and in its offspring.	2
Statement B4.r5x	**Recombinant DNA** Recombinant DNA technology allows scientists in the laboratory to combine the genes from different sources, sometimes different species, into a single DNA molecule. This manipulation of genes using bacterial plasmids has been used for many practical purposes including the mass production of chemicals and drugs. *(recommended)*	
B4.r5a	Explain how recombinant DNA technology allows scientists to analyze the structure and function of genes *(recommended)*	R
B4.r5b	Evaluate the advantages and disadvantages of human manipulation of DNA *(recommended)*	R
Standard B5	**EVOLUTION AND BIODIVERSITY**	
Statement L5.p1	**Survival and Extinction *(prerequisite)*** Individual organisms with certain traits in particular environments are more likely than others to survive and have offspring. When an environment changes, the advantage or disadvantage of characteristics can change. Extinction of a species occurs when the environment changes and the characteristics of a species are insufficient to allow survival. Fossils indicate that many organisms that lived long ago are extinct. Extinction of species is common; most of the species that have lived on the Earth no longer exist. *(prerequisite)*	
L5.p1A	Define a species and give examples. *(prerequisite)*	P

HSCE Code	Expectation	DOK
L5.p1B	Define a population and identify local populations *(prerequisite)*	P
L5.p1C	Explain how extinction removes genes from the gene pool. *(prerequisite)*	P
L5.p1D	Explain the importance of the fossil record. *(prerequisite)*	P
Statement L5.p2	**Classification *(prerequisite)*** Similarities among organisms are found in anatomical features, which can be used to infer the degree of relatedness among organisms In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance. *(prerequisite)*	
L5 p2A	Explain, with examples, that ecology studies the varieties and interactions of living things across space while evolution studies the varieties and interactions of living things across time. *(prerequisite)*	P
Statement B5.1	**Theory of Evolution** The theory of evolution provides a scientific explanation for the history of life on Earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.	
B5.1A	Summarize the major concepts of natural selection (differential survival and reproduction of chance inherited variants, depending on environmental conditions).	1
B5.1B	Describe how natural selection provides a mechanism for evolution.	1
B5.1c	Summarize the relationships between present-day organisms and those that inhabited the Earth in the past (e g., use fossil record, embryonic stages, homologous structures, chemical basis).	2
B5.1d	Explain how a new species or variety originates through he evolutionary process of natural selection.	2
B5 1e	Explain how natural selection leads to organisms that are well suited for the environment (differential survival and reproduction of chance inherited variants, depending upon environmental conditions).	2
B5.1f	Explain, using examples, how the fossil record, comparative anatomy, and other evidence supports the theory of evolution.	2
B5.1g	Illustrate how genetic variation is preserved or eliminated from a population through natural selection (evolution) resulting in biodiversity.	2
Statement B5.2x	**Molecular Evidence** Molecular evidence substantiates the anatomical evidence for evolution and provides additional detail about the sequence in which various lines of descents branched.	
B5.2a	Describe species as reproductively distinct groups of organisms that can be classified based on morphological, behavioral, and molecular similarities.	1
B5.2b	Explain that the degree of kinship between organisms or species can be estimated from the similarity of their DNA and protein sequences.	2
B5 2c	Trace the relationship between environmental changes and changes in the gene pool, such as genetic drift and isolation of subpopulations.	2
B5.r2d	Interpret a cladogram or phylogenetic tree showing evolutionary relationships among organisms *(recommended)*	R
Statement B5.3	**Natural Selection** Evolution is the consequence of natural selection, the interactions of (1) the potential for a population to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection from environmental pressure of those organisms better able to survive and leave offspring.	
B5 3A	Explain how natural selection acts on individuals, but it is populations that evolve. Relate genetic mutations and genetic variety produced by sexual reproduction to diversity within a given population.	3
B5.3B	Describe the role of geographic isolation in speciation.	1
B5.3C	Give examples of ways in which genetic variation and environmental factors are causes of evolution and the diversity of organisms.	1
B5.3d	Explain how evolution through natural selection can result in changes in biodiversity.	1
B5 3e	Explain how changes at the gene level are the foundation for changes in populations and eventually the formation of new species.	1
B5.3f	Demonstrate and explain how biotechnology can improve a population and species.	2

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HSCE Code	Expectation	DOK
Standard C1	**INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS**	
Statement C1.1	**Scientific Inquiry** Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	
C1.1A	Generate new questions that can be investigated in the laboratory or field.	3
C1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	3
C1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	2
C1.1D	Identify patterns in data and relate them to theoretical models.	2
C1.1E	Describe a reason for a given conclusion using evidence from an investigation.	3
C1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.	3
C1.1g	Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.	3
C1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	3
C1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	2
Statement C1.2	**Scientific Reflection and Social Implications** The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	
C1.2A	Critique whether or not specific questions can be answered through scientific investigations.	3
C1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence	3
C1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information	3
C1.2D	Evaluate scientific explanations in a peer review process or discussion format.	3
C1.2E	Evaluate the future career and occupational prospects of science fields.	2
C1.2f	Critique solutions to problems, given criteria and scientific constraints.	3
C1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions.	2
C1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.	2
C1.2i	Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.	2
C1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions.	3
C1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	2

HSCE Code	Expectation	DOK
Standard C2	**FORMS OF ENERGY**	
Statement P2.p1	**P2.p1 Potential Energy** ***(prerequisite)*** Three forms of potential energy are gravitational, elastic, and chemical. Objects can have elastic potential energy due to their compression or chemical potential energy due to the arrangement of the atoms. *(prerequisite)*	
P2.p1A	Describe energy changes associated with changes of state in terms of the arrangement and order of the atoms (molecules) in each state. *(prerequisite)*	P
P2.p1B	Use the positions and arrangements of atoms and molecules in solid, liquid, and gas state to explain the need for an input of energy for melting and boiling and a release of energy in condensation and freezing. *(prerequisite)*	P
Statement C2.1x	**Chemical Potential Energy** Potential energy is stored whenever work must be done to change the distance between two objects. The attraction between the two objects may be gravitational, electrostatic, magnetic, or strong force. Chemical potential energy is the result of electrostatic attractions between atoms.	
C2.1a	Explain the changes in potential energy (due to electrostatic interactions) as a chemical bond forms and use this to explain why bond breaking always requires energy.	2
C2.1b	Describe energy changes associated with chemical reactions in terms of bonds broken and formed (including intermolecular forces).	1
C2.1c	Compare qualitatively the energy changes associated with melting various types of solids in terms of the types of forces between the particles in the solid.	2
Statement C2.2	**Molecules in Motion** Molecules that compose matter are in constant motion (translational, rotational, and vibrational). Energy may be transferred from one object to another during collisions between molecules.	
C2.2A	Describe conduction in terms of molecules bumping into each other to transfer energy. Explain why there is better conduction in solids and liquids than gases.	2
C2.2B	Describe the various states of matter in terms of the motion and arrangement of the molecules (atoms) making up the substance.	1
Statement C2.2x	**Molecular Entropy** As temperature increases, the average kinetic energy and the entropy of the molecules in a sample increases.	
C2.2c	Explain changes in pressure, volume, and temperature for gases using the kinetic molecular model.	1
C2.2d	Explain convection and the difference in transfer of thermal energy for solids, liquids, and gases using evidence that molecules are in constant motion.	2
C2.2e	Compare the entropy of solids, liquids, and gases.	2
C2.2f	Compare the average kinetic energy of the molecules in a metal object and a wood object at room temperature.	2
Statement C2.3x	**Breaking Chemical Bonds** For molecules to react, they must collide with enough energy (activation energy) to break old chemical bonds before their atoms can be rearranged to form new substances.	
C2.3a	Explain how the rate of a given chemical reaction is dependent on the temperature and the activation energy.	1
C2.3b	Draw and analyze a diagram to show the activation energy for an exothermic reaction that is very slow at room temperature.	2
Statement C2.4x	**Electron Movement** For each element, the arrangement of electrons surrounding the nucleus is unique. These electrons are found in different energy levels and can only move from a lower energy level (closer to nucleus) to a higher energy level (farther from nucleus) by absorbing energy in discrete packets. The energy content of the packets is directly proportional to the frequency of the radiation. These electron transitions will produce unique absorption spectra for each element. When the electron returns from an excited (high energy state) to a lower energy state, energy is emitted in only certain wavelengths of light, producing an emission spectra.	
C2.4a	Describe energy changes in flame tests of common elements in terms of the (characteristic) electron transitions.	1
C2.4b	Contrast the mechanism of energy changes and the appearance of absorption and emission spectra.	2
C2.4c	Explain why an atom can absorb only certain wavelengths of light.	1
C2.4d	Compare various wavelengths of light (visible and nonvisible) in terms of frequency and relative energy.	2

HSCE Code	Expectation	DOK
Statement C2.5x	**Nuclear Stability** Nuclear stability is related to a decrease in potential energy when the nucleus forms from protons and neutrons. If the neutron/proton ratio is unstable, the element will undergo radioactive decay. The rate of decay is characteristic of each isotope; the time for half the parent nuclei to decay is called the half-life. Comparison of the parent/daughter nuclei can be used to determine the age of a sample. Heavier elements are formed from the fusion of lighter elements in the stars.	
C2.5a	Determine the age of materials using the ratio of stable and unstable isotopes of a particular type.	1
C2.r5b	Illustrate how elements can change in nuclear reactions using balanced equations. *(recommended)*	R
C2.r5c	Describe the potential energy changes as two protons approach each other. *(recommended)*	R
C2.r5d	Describe how and where all the elements on earth were formed. *(recommended)*	R
Standard C3	**ENERGY TRANSFER AND CONSERVATION**	
Statement P3.p1	**Conservation of Energy *(prerequisite)*** When energy is transferred from one system to another, the quantity of energy before transfer equals the quantity of energy after transfer. *(prerequisite)*	
P3.p1A	Explain that the amount of energy necessary to heat a substance will be the same as the amount of energy released when the substance is cooled to the original temperature. *(prerequisite)*	P
Statement C3.1x	**Hess's Law** For chemical reactions where the state and amounts of reactants and products are known, the amount of energy transferred will be the same regardless of the chemical pathway. This relationship is called Hess's law.	
C3.1a	Calculate the ΔH for a given reaction using Hess's Law.	1
C3.1b	Draw enthalpy diagrams for exothermic and endothermic reactions.	1
C3.1c	Calculate the ΔH for a chemical reaction using simple coffee cup calorimetry	1
C3.1d	Calculate the amount of heat produced for a given mass of reactant from a balanced chemical equation.	1
Statement P3.P2	**P3.p2 Energy Transfer *(prerequisite)*** Nuclear reactions take place in the sun. In plants, light from the sun is transferred to oxygen and carbon compounds, which, in combination, have chemical potential energy (photosynthesis). *(prerequisite)*	
P3.P2a	Trace (or diagram) energy transfers involving various types of energy including nuclear, chemical, electrical, sound, and light. *(prerequisite)*	P
Statement C3.2x	**Enthalpy** Chemical reactions involve breaking bonds in reactants (endothermic) and forming new bonds in the products (exothermic). The enthalpy change for a chemical reaction will depend on the relative strengths of the bonds in the reactants and products.	
C3.2a	Describe the energy changes in photosynthesis and in the combustion of sugar in terms of bond breaking and bond making.	1
C3.2b	Describe the relative strength of single, double, and triple covalent bonds between nitrogen atoms	1
Statement C3.3	**Heating Impacts** Heating increases the kinetic (translational, rotational, and vibrational) energy of the atoms composing elements and the molecules or ions composing compounds. As the kinetic (translational) energy of the atoms, molecules, or ions increases, the temperature of the matter increases. Heating a sample of a crystalline solid increases the kinetic (vibrational) energy of the atoms, molecules, or ions. When the kinetic (vibrational) energy becomes great enough, the crystalline structure breaks down, and the solid melts.	
C3.3A	Describe how heat is conducted in a solid	1
C3.3B	Describe melting on a molecular level	1
Statement C3.3x	**Bond Energy** Chemical bonds possess potential (vibrational and rotational) energy.	
C3.3c	Explain why it is necessary for a molecule to absorb energy in order to break a chemical bond.	2

HSCE Code	Expectation	DOK
Statement C3.4	**Endothermic and Exothermic Reactions** Chemical interactions either release energy to the environment (exothermic) or absorb energy from the environment (endothermic).	
C3.4A	Use the terms endothermic and exothermic correctly to describe chemical reactions in the laboratory.	1
C3.4B	Explain why chemical reactions will either release or absorb energy.	2
Statement C3.4x	**Enthalpy and Entropy** All chemical reactions involve rearrangement of the atoms. In an exothermic reaction, the products have less energy than the reactants. There are two natural driving forces: (1) toward minimum energy (enthalpy) and (2) toward maximum disorder (entropy).	
C3.4c	Write chemical equations including the heat term as a part of equation or using ΔH notation.	1
C3.4d	Draw enthalpy diagrams for reactants and products in endothermic and exothermic reactions.	1
C3.4e	Predict if a chemical reaction is spontaneous given the enthalpy (ΔH) and entropy (ΔS) changes for the reaction using Gibb's Free Energy, $\Delta G = \Delta H - T\Delta S$ (Note: mathematical computation of ΔG is not required.)	2
C3.4f	Explain why some endothermic reactions are spontaneous at room temperature.	1
C3.4g	Explain why gases are less soluble in warm water than cold water.	1
C3.5x	**Mass Defect** Nuclear reactions involve energy changes many times the magnitude of chemical changes. In chemical reactions matter is conserved, but in nuclear reactions a small loss in mass (mass defect) will account for the tremendous release of energy. The energy released in nuclear reactions can be calculated from the mass defect using $E = mc2$.	
C3.5a	Explain why matter is not conserved in nuclear reactions.	1
Standard C4	**PROPERTIES OF MATTER**	
Statement P4.p1	**Kinetic Molecular Theory *(prerequisite)*** Properties of solids, liquids, and gases are explained by a model of matter that is composed of tiny particles in motion. *(prerequisite)*	
P4.p1A	For a substance that can exist in all three phases, describe the relative motion of the particles in each of the phases. (prerequisite)	**P**
P4.p1B	For a substance that can exist in all three phases, make a drawing that shows the arrangement and relative spacing of the particles in each of the phases. *(prerequisite)*	P
P4.p1C	For a simple compound, present a drawing that shows the number of particles in the system does not change as a result of a phase change. *(prerequisite)*	P
Statement P4.p2	**Elements, Compounds, and Mixtures *(prerequisite)*** Elements are a class of substances composed of a single kind of atom. Compounds are composed of two or more different elements chemically combined. Mixtures are composed of two or more different elements and/or compounds physically combined. Each element and compound has physical and chemical properties, such as boiling point, density, color, and conductivity, which are independent of the amount of the sample. *(prerequisite)*	
P4.p2A	Distinguish between an element, compound, or mixture based on drawings or formulae. *(prerequisite)*	P
P4.p2B	Identify a pure substance (element or compound) based on unique chemical and physical properties *(prerequisite)*	P
P4.p2C	Separate mixtures based on the differences in physical properties of the individual components *(prerequisite)*	P
P4.p2D	Recognize that the properties of a compound differ from those of its individual elements *(prerequisite)*	P
Statement C4.1x	**Molecular and Empirical Formulae** Compounds have a fixed percent elemental composition. For a compound, the empirical formula can be calculated from the percent composition or the mass of each element. To determine the molecular formula from the empirical formula, the molar mass of the substance must also be known.	
C4.1a	Calculate the percent by weight of each element in a compound based on the compound formula	1
C4.1b	Calculate the empirical formula of a compound based on the percent by weight of each element in the compound.	1
C4.1c	Use the empirical formula and molecular weight of a compound to determine the molecular formula	1

HSCE Code	Expectation	DOK
Statement C4.2	**Nomenclature** All compounds have unique names that are determined systematically.	
C4.2A	Name simple binary compounds using their formulae	1
C4.2B	Given the name, write the formula of simple binary compounds.	1
Statement C4.2x	**Nomenclature** All molecular and ionic compounds have unique names that are determined systematically.	
C4.2c	Given a formula, name the compound.	1
C4.2d	Given the name, write the formula of ionic and molecular compounds.	1
C4.2e	Given the formula for a simple hydrocarbon, draw and name the isomers.	1
Statement C4.3	**Properties of Substances** Differences in the physical and chemical properties of substances are explained by the arrangement of the atoms, ions, or molecules of the substances and by the strength of the forces of attraction between the atoms, ions, or molecules.	
C4.3A	Recognize that substances that are solid at room temperature have stronger attractive forces than liquids at room temperature, which have stronger attractive forces than gases at room temperature.	1
C4.3B	Recognize that solids have a more ordered, regular arrangement of their particles than liquids and that liquids are more ordered than gases.	1
Statement C4.3x	**Solids** Solids can be classified as metallic, ionic, covalent, or network covalent. These different types of solids have different properties that depend on the particles and forces found in the solid	
C4.3c	Compare the relative strengths of forces between molecules based on the melting point and boiling point of the substances.	2
C4.3d	Compare the strength of the forces of attraction between molecules of different elements. (For example, at room temperature, chlorine is a gas and iodine is a solid.)	2
C4.3e	Predict whether the forces of attraction in a solid are primarily metallic, covalent, network covalent, or ionic based upon the elements' location on the periodic table.	2
C4.3f	Identify the elements necessary for hydrogen bonding (N, O, F).	1
C4.3g	Given the structural formula of a compound, indicate all the intermolecular forces present (dispersion, dipolar, hydrogen bonding).	1
C4.3h	Explain properties of various solids such as malleability, conductivity, and melting point in terms of the solid's structure and bonding.	1
C4.3i	Explain why ionic solids have higher melting points than covalent solids. (For example, NaF has a melting point of 995°C while water has a melting point of 0° C.)	1
Statement C4.4x	**Molecular Polarity** The forces between molecules depend on the net polarity of the molecule as determined by shape of the molecule and the polarity of the bonds.	
C4.4a	Explain why at room temperature different compounds can exist in different phases.	2
C4.4b	Identify if a molecule is polar or nonpolar given a structural formula for the compound.	1
Statement C4.5x	**Ideal Gas Law** The forces in gases are explained by the ideal gas law.	
C4.5a	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-volume relationship in gases.	2
C4.5b	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the pressure-temperature relationship in gases.	2
C4.5c	Provide macroscopic examples, atomic and molecular explanations, and mathematical representations (graphs and equations) for the temperature-volume relationship in gases.	2

HSCE Code	Expectation	DOK
Statement C4.6x	**Moles** The mole is the standard unit for counting atomic and molecular particles in terms of common mass units.	
C4.6a	Calculate the number of moles of any compound or element given the mass of the substance.	1
C4 6b	Calculate the number of particles of any compound or element given the mass of the substance.	1
Statement C4.7x	**Solutions** The physical properties of a solution are determined by the concentration of solute.	
C4.7a	Investigate the difference in the boiling point or freezing point of pure water and a salt solution	2
C4.7b	Compare the density of pure water to that of a sugar solution.	2
Statement C4.8	**Atomic Structure** Electrons, protons, and neutrons are parts of the atom and have measurable properties, including mass and, in the case of protons and electrons, charge. The nuclei of atoms are composed of protons and neutrons A kind of force that is only evident at nuclear distances holds the particles of the nucleus together against the electrical repulsion between the protons.	
C4 8A	Identify the location, relative mass, and charge for electrons, protons, and neutrons.	1
C4.8B	Describe the atom as mostly empty space with an extremely small, dense nucleus consisting of the protons and neutrons and an electron cloud surrounding the nucleus.	1
C4.8C	Recognize that protons repel each other and that a strong force needs to be present to keep the nucleus intact	1
C4 8D	Give the number of electrons and protons present if the fluoride ion has a -1 charge	1
Statement C4.8x	**Electron Configuration** Electrons are arranged in main energy levels with sublevels that specify particular shapes and geometry Orbitals represent a region of space in which an electron may be found with a high level of probability. Each defined orbital can hold two electrons, each with a specific spin orientation The specific assignment of an electron to an orbital is determined by a set of 4 quantum numbers Each element and, therefore, each position in the periodic table is defined by a unique set of quantum numbers.	
C4.8e	Write the complete electron configuration of elements in the first four rows of the periodic table.	1
C4.8f	Write kernel structures for main group elements.	1
C4.8g	Predict oxidation states and bonding capacity for main group elements using their electron structure	2
C4 8h	Describe the shape and orientation of *s* and *p* orbitals	1
C4.8i	Describe the fact that the electron location cannot be exactly determined at any given time	1
Statement C4.9	**Periodic Table** In the periodic table, elements are arranged in order of increasing number of protons (called the atomic number) Vertical groups in the periodic table (families) have similar physical and chemical properties due to the same outer electron structures.	
C4.9A	Identify elements with similar chemical and physical properties using the periodic table.	1
Statement C4.9x	**Electron Energy Levels** The rows in the periodic table represent the main electron energy levels of the atom Within each main energy level are sublevels that represent an orbital shape and orientation.	
C4.9b	Identify metals, non-metals, and metalloids using the periodic table.	1
C4.9c	Predict general trends in atomic radius, first ionization energy, and electonegativity of the elements using the periodic table.	1

HSCE Code	Expectation	DOK
Statement C4.10	**Neutral Atoms, Ions, and Isotopes** A neutral atom of any element will contain the same number of protons and electrons. Ions are charged particles with an unequal number of protons and electrons. Isotopes are atoms of the same element with different numbers of neutrons and essentially the same chemical and physical properties.	
C4.10A	List the number of protons, neutrons, and electrons for any given ion or isotope.	1
C4.10B	Recognize that an element always contains the same number of protons	1
Statement C4.10x	**Average Atomic Mass** The atomic mass listed on the periodic table is an average mass for all the different isotopes that exist, taking into account the percent and mass of each different isotope.	
C4.10c	Calculate the average atomic mass of an element given the percent abundance and mass of the individual isotopes.	1
C4.10d	Predict which isotope will have the greatest abundance given the possible isotopes for an element and the average atomic mass in the periodic table.	2
C4.10e	Write the symbol for an isotope, $^{A}_{Z}X$, where Z is the atomic number, A is the mass number, and X is the symbol for the element.	1
Standard C5	**CHANGES IN MATTER**	
Statement P5.p1	**Conservation of Matter *(prerequisite)*** Changes of state are explained by a model of matter composed of tiny particles that are in motion. When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure. Mass is conserved when substances undergo changes of state. *(prerequisite)*	
P5.p1A	Draw a picture of the particles of an element or compound as a solid, liquid, and gas. *(prerequisite)*	P
Statement C5.r1x	**Rates of Reactions *(recommended)*** The rate of a chemical reaction will depend upon (1) concentration of reacting species, (2) temperature of reaction, (3) pressure if reactants are gases, and (4) nature of the reactants. A model of matter composed of tiny particles that are in constant motion is used to explain rates of chemical reactions. *(recommended)*	
C5.r1a	Predict how the rate of a chemical reaction will be influenced by changes in concentration, temperature, and pressure. *(recommended)*	R
C5.r1b	Explain how the rate of a reaction will depend on concentration, temperature, pressure, and nature of reactant. *(recommended)*	R
Statement C5.2	**Chemical Changes** Chemical changes can occur when two substances, elements, or compounds interact and produce one or more different substances whose physical and chemical properties are different from the interacting substances. When substances undergo chemical change, the number of atoms in the reactants is the same as the number of atoms in the products. This can be shown through simple balancing of chemical equations. Mass is conserved when substances undergo chemical change. The total mass of the interacting substances (reactants) is the same as the total mass of the substances produced (products).	
C5.2A	Balance simple chemical equations applying the conservation of matter.	2
C5.2B	Distinguish between chemical and physical changes in terms of the properties of the reactants and products.	2
C5.2C	Draw pictures to distinguish the relationships between atoms in physical and chemical changes.	2
Statement C5.2x	**Balancing Equations** A balanced chemical equation will allow one to predict the amount of product formed.	
C5.2d	Calculate the mass of a particular compound formed from the masses of starting materials.	1
C5.2e	Identify the limiting reagent when given the masses of more than one reactant.	2
C5.2f	Predict volumes of product gases using initial volumes of gases at the same temperature and pressure.	1
C5.2g	Calculate the number of atoms present in a given mass of element.	1
Statement C5.3x	**Equilibrium** Most chemical reactions reach a state of dynamic equilibrium where the rates of the forward and reverse reactions are equal.	
C5.3a	Describe equilibrium shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).	1
C5.3b	Predict shifts in a chemical system caused by changing conditions (Le Chatelier's Principle).	2
C5.3c	Predict the extent reactants are converted to products using the value of the equilibrium constant.	2

HSCE Code	Expectation	DOK
Statement C5.4	**Phase Change/Diagrams** Changes of state require a transfer of energy. Water has unusually high-energy changes associated with its changes of state.	
C5.4A	Compare the energy required to raise the temperature of one gram of aluminum and one gram of water the same number of degrees.	2
C5.4B	Measure, plot, and interpret the graph of the temperature versus time of an ice-water mixture, under slow heating, through melting and boiling.	2
Statement C5.4x	**Changes of State** All changes of state require energy. Changes in state that require energy involve breaking forces holding the particles together. The amount of energy will depend on the type of forces.	
C5.4c	Explain why both the melting point and boiling points for water are significantly higher than other small molecules of comparable mass (e.g., ammonia and methane).	2
C5.4d	Explain why freezing is an exothermic change of state.	2
C5.4e	Compare the melting point of covalent compounds based on the strength of IMFs (intermolecular forces).	2
Statement C5.5	**Chemical Bonds — Trends** An atom's electron configuration, particularly of the outermost electrons, determines how the atom can interact with other atoms. The interactions between atoms that hold them together in molecules or between oppositely charged ions are called chemical bonds.	
C5.5A	Predict if the bonding between two atoms of different elements will be primarily ionic or covalent.	2
C5.5B	Predict the formula for binary compounds of main group elements.	2
Statement C5.5x	**Chemical Bonds** Chemical bonds can be classified as ionic, covalent, and metallic. The properties of a compound depend on the types of bonds holding the atoms together.	
C5.5c	Draw Lewis structures for simple compounds.	1
C5.5d	Compare the relative melting point, electrical and thermal conductivity, and hardness for ionic, metallic, and covalent compounds.	2
C5.5e	Relate the melting point, hardness, and electrical and thermal conductivity of a substance to its structure.	2
Statement C5.6x	**Reduction/Oxidation Reactions** Chemical reactions are classified according to the fundamental molecular or submolecular changes that occur. Reactions that involve electron transfer are known as oxidation/ reduction (or "redox").	
C5.6a	Balance half-reactions and describe them as oxidations or reductions.	2
C5.6b	Predict single replacement reactions.	1
C5.6c	Explain oxidation occurring when two different metals are in contact.	1
C5.6d	Calculate the voltage for spontaneous redox reactions from the standard reduction potentials.	1
C5.6e	Identify the reactions occurring at the anode and cathode in an electrochemical cell.	1
Statement C5.7	**Acids and Bases** Acids and bases are important classes of chemicals that are recognized by easily observed properties in the laboratory. Acids and bases will neutralize each other. Acid formulas usually begin with hydrogen, and base formulas are a metal with a hydroxide ion. As the pH decreases, a solution becomes more acidic. A difference of one pH unit is a factor of 10 in hydrogen ion concentration.	
C5.7A	Recognize formulas for common inorganic acids, carboxylic acids, and bases formed from families I and II.	1
C5.7B	Predict products of an acid-based neutralization.	2
C5.7C	Describe tests that can be used to distinguish an acid from a base.	1
C5.7D	Classify various solutions as acidic or basic, given their pH.	1
C5.7E	Explain why lakes with limestone or calcium carbonate experience less adverse effects from acid rain than lakes with granite beds.	2
Statement C5.7x	**Brønsted-Lowry** Chemical reactions are classified according to the fundamental molecular or submolecular changes that occur. Reactions that involve proton transfer are known as acid/base reactions.	
C5.7f	Write balanced chemical equations for reactions between acids and bases and perform calculations with balanced equations.	1
C5.7g	Calculate the pH from the hydronium ion or hydroxide ion concentration.	1

HSCE Code	Expectation	DOK
C5.7h	Explain why sulfur oxides and nitrogen oxides contribute to acid rain.	1
C5.r7i	Identify the Brønsted-Lowry conjugate acid-base pairs in an equation. *(recommended)*	R
Statement C5.8	**Carbon Chemistry** The chemistry of carbon is important. Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.	
C5.8A	Draw structural formulas for up to ten carbon chains of simple hydrocarbons.	1
C5.8B	Draw isomers for simple hydrocarbons.	1
C5.8C	Recognize that proteins, starches, and other large biological molecules are polymers.	1

HSCE Code	Expectation	DOK
Standard E1	**INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS**	
Statement E1.1	**Scientific Inquiry** Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	
E1.1A	Generate new questions that can be investigated in the laboratory or field.	3
E1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	3
E1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity—length, volume, weight, time interval, temperature—with the appropriate level of precision).	2
E1.1D	Identify patterns in data and relate them to theoretical models.	2
E1.1E	Describe a reason for a given conclusion using evidence from an investigation.	3
E1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.	3
E1.1g	Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation	3
E1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	3
E1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate	2
Statement E1.2	**Scientific Reflection and Social Implications** The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	
E1.2A	Critique whether or not specific questions can be answered through scientific investigations.	3
E1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence.	3
E1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	3
E1.2D	Evaluate scientific explanations in a peer review process or discussion format.	3
E1.2E	Evaluate the future career and occupational prospects of science fields.	2
E1.2f	Critique solutions to problems, given criteria and scientific constraints	3
E1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions.	2
E1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.	2
E1.2i	Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.	2
E1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions	3
E1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	2

HSCE Code	Expectation	DOK
Standard E2	**EARTH SYSTEMS**	
Statement E2.1	**Earth Systems Overview** The Earth is a system consisting of four major interacting components: geosphere (crust, mantle, and core), atmosphere (air), hydrosphere (water), and biosphere (the living part of Earth). Physical, chemical, and biological processes act within and among the four components on a wide range of time scales to continuously change Earth's crust, oceans, atmosphere, and living organisms. Earth elements move within and between the lithosphere, atmosphere, hydrosphere, and biosphere as part of geochemical cycles	
E2.1A	Explain why the Earth is essentially a closed system in terms of matter.	1
E2.1B	Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere) that make up the Earth.	2
E2.1C	Explain, using specific examples, how a change in one system affects other Earth systems.	2
Statement E2.2	**Energy in Earth Systems** Energy in Earth systems can exist in a number of forms (e.g., thermal energy as heat in the Earth, chemical energy stored as fossil fuels, mechanical energy as delivered by tides) and can be transformed from one state to another and move from one reservoir to another. Movement of matter and its component elements, through and between Earth's systems, is driven by Earth's internal (radioactive decay and gravity) and external (Sun as primary) sources of energy. Thermal energy is transferred by radiation, convection, and conduction. Fossil fuels are derived from plants and animals of the past, are nonrenewable and, therefore, are limited in availability. All sources of energy for human consumption (e.g., solar, wind, nuclear, ethanol, hydrogen, geothermal, hydroelectric) have advantages and disadvantages.	
E2.2A	Describe the Earth's principal sources of internal and external energy (e.g., radioactive decay, gravity, solar energy).	1
E2.2B	Identify differences in the origin and use of renewable (e.g., solar, wind, water, biomass) and nonrenewable (e.g., fossil fuels, nuclear [U-235]) sources of energy.	2
E2.2C	Describe natural processes in which heat transfer in the Earth occurs by conduction, convection, and radiation.	1
E2.2D	Identify the main sources of energy to the climate system.	1
E2.2e	Explain how energy changes form through Earth systems.	2
E2.2f	Explain how elements exist in different compounds and states as they move from one reservoir to another.	2
Statement E2.3	**Biogeochemical Cycles** The Earth is a system containing essentially a fixed amount of each stable chemical atom or element. Most elements can exist in several different states and chemical forms; they move within and between the geosphere, atmosphere, hydrosphere, and biosphere as part of the Earth system. The movements can be slow or rapid. Elements and compounds have significant impacts on the biosphere and have important impacts on human health.	
E2.3A	Explain how carbon exists in different forms such as limestone (rock), carbon dioxide (gas), carbonic acid (water), and animals (life) within Earth systems and how those forms can be beneficial or harmful to humans.	2
E2.3b	Explain why small amounts of some chemical forms may be beneficial for life but are poisonous in large quantities (e.g., dead zone in the Gulf of Mexico, Lake Nyos in Africa, fluoride in drinking water).	1
E2.3c	Explain how the nitrogen cycle is part of the Earth system.	1
E2.3d	Explain how carbon moves through the Earth system (including the geosphere) and how it may benefit (e.g., improve soils for agriculture) or harm (e.g., act as a pollutant) society.	2
Statement E2.4	**Resources and Human Impacts on Earth Systems** The Earth provides resources (including minerals) that are used to sustain human affairs. The supply of non-renewable natural resources is limited and their extraction and use can release elements and compounds into Earth systems. They affect air and water quality, ecosystems, landscapes, and may have effects on long-term climate. Plans for land use and long-term development must include an understanding of the interactions between Earth systems and human activities.	
E2.4A	Describe renewable and nonrenewable sources of energy for human consumption (electricity, fuels), compare their effects on the environment, and include overall costs and benefits.	2
E2.4B	Explain how the impact of human activities on the environment (e.g., deforestation, air pollution, coral reef destruction) can be understood through the analysis of interactions between the four Earth systems.	2
E2.4c	Explain ozone depletion in the stratosphere and methods to slow human activities to reduce ozone depletion.	1
E2.4d	Describe the life cycle of a product, including the resources, production, packaging, transportation, disposal, and pollution.	1

HSCE Code	Expectation	DOK
Standard E3	**THE SOLID EARTH**	
Statement E3.p1	**Landforms and Soils *(prerequisite)*** Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruptions, and deposition of sediments transported in rivers, streams, and lakes through watersheds. Destructive forces include weathering and erosion. The weathering of rocks and decomposed organic matter result in the formation of soils. *(prerequisite)*	
E3.p1A	Explain the origin of Michigan landforms. Describe and identify surface features using maps and satellite images. *(prerequisite)*	P
E3.p1B	Explain how physical and chemical weathering leads to erosion and the formation of soils and sediments. *(prerequisite)*	P
E3.p1C	Describe how coastal features are formed by wave erosion and deposition. *(prerequisite)*	P
Statement E3.p2	**Rocks and Minerals *(prerequisite)*** Igneous, metamorphic, and sedimentary rocks are constantly forming and changing through various processes. As they do so, elements move through the geosphere. In addition to other geologic features, rocks and minerals are indicators of geologic and environmental conditions that existed in the past. *(prerequisite)*	
E3.p2A	Identify common rock-forming minerals (quartz, feldspar, biotite, calcite, hornblende). *(prerequisite)*	P
E3.p2B	Identify common igneous (granite, basalt, andesite, obsidian, pumice), metamorphic (schist, gneiss, marble, slate, quartzite), and sedimentary (sandstone, limestone, shale, conglomerate) rocks and describe the processes that change one kind of rock to another. *(prerequisite)*	P
Statement E3.p3	**Basic Plate Tectonics *(prerequisite)*** Early evidence for the movement of continents was based on the similarities of coastlines, geology, faunal distributions, and paleoclimatological data across the Atlantic and Indian Oceans. In the 1960s, additional evidence from marine geophysical surveys, seismology, volcanology, and paleomagnetism resulted in the development of the theory of plate tectonics. *(prerequisite)*	
E3.p3A	Describe geologic, paleontologic, and paleoclimatalogic evidence that indicates Africa and South America were once part of a single continent. *(prerequisite)*	P
E3.p3B	Describe the three types of plate boundaries (divergent, convergent, and transform) and geographic features associated with them (e.g., continental rifts and mid-ocean ridges, volcanic and island arcs, deep-sea trenches, transform faults). *(prerequisite)*	P
E3.p3C	Describe the three major types of volcanoes (shield volcano, stratovolcano, and cinder cones) and their relationship to the Ring of Fire. *(prerequisite)*	P
Statement E3.1	**Advanced Rock Cycle** Igneous, metamorphic, and sedimentary rocks are indicators of geologic and environmental conditions and processes that existed in the past. These include cooling and crystallization, weathering and erosion, sedimentation and lithification, and metamorphism. In some way, all of these processes are influenced by plate tectonics, and some are influenced by climate.	
E3.1A	Discriminate between igneous, metamorphic, and sedimentary rocks and describe the processes that change one kind of rock into another.	2
E3.1B	Explain the relationship between the rock cycle and plate tectonics theory in regard to the origins of igneous, sedimentary, and metamorphic rocks.	2
E3.1c	Explain how the size and shape of grains in a sedimentary rock indicate the environment of formation (including climate) and deposition.	2
E3.1d	Explain how the crystal sizes of igneous rocks indicate the rate of cooling and whether the rock is extrusive or intrusive.	1
E3.1e	Explain how the texture (foliated, nonfoliated) of metamorphic rock can indicate whether it has experienced regional or contact metamorphism.	1
Statement E3.2	**Interior of the Earth** The Earth can also be subdivided into concentric layers based on their physical characteristics: (lithosphere, asthenosphere, lower mantle, outer core, and inner core). The crust and upper mantle compose the rigid lithosphere (plates) that moves over a "softer" asthenosphere (part of the upper mantle). The magnetic field of the Earth is generated in the outer core. The interior of the Earth cannot be directly sampled and must be modeled using data from seismology.	
E3.2A	Describe the interior of the Earth (in terms of crust, mantle, and inner and outer cores) and where the magnetic field of the Earth is generated.	1

HSCE Code	Expectation	DOK
E3.2B	Explain how scientists infer that the Earth has interior layers with discernable properties using patterns of primary (*P*) and secondary (*S*) seismic wave arrivals.	1
E3.2C	Describe the differences between oceanic and continental crust (including density, age, composition).	1
E3.2d	Explain the uncertainties associated with models of the interior of the Earth and how these models are validated.	2
Statement E3.3	**Plate Tectonics Theory** The Earth's crust and upper mantle make up the lithosphere, which is broken into large mobile pieces called tectonic plates. The plates move at velocities in units of centimeters per year as measured using the global positioning system (GPS). Motion histories are determined with calculations that relate rate, time, and distance of offset geologic features. Oceanic plates are created at mid-ocean ridges by magmatic activity and cooled until they sink back into the Earth at subduction zones. At some localities, plates slide by each other. Mountain belts are formed both by continental collision and as a result of subduction. The outward flow of heat from Earth's interior provides the driving energy for plate tectonics.	
E3.3A	Explain how plate tectonics accounts for the features and processes (sea floor spreading, mid-ocean ridges, subduction zones, earthquakes and volcanoes, mountain ranges) that occur on or near the Earth's surface.	1
E3.3B	Explain why tectonic plates move using the concept of heat flowing through mantle convection, coupled with the cooling and sinking of aging ocean plates that result from their increased density.	2
E3.3C	Describe the motion history of geologic features (e.g., plates, Hawaii) using equations relating rate, time, and distance.	1
E3.3d	Distinguish plate boundaries by the pattern of depth and magnitude of earthquakes.	2
E3.r3e	Predict the temperature distribution in the lithosphere as a function of distance from the mid-ocean ridge and how it relates to ocean depth. *(recommended)*	R
E3.r3f	Describe how the direction and rate of movement for the North American plate has affected the local climate over the last 600 million years. *(recommended)*	R
Statement E3.4	**Earthquakes and Volcanoes** Plate motions result in potentially catastrophic events (earthquakes, volcanoes, tsunamis, mass wasting) that affect humanity. The intensity of volcanic eruptions is controlled by the chemistry and properties of the magma. Earthquakes are the result of abrupt movements of the Earth. They generate energy in the form of body and surface waves.	
E3.4A	Use the distribution of earthquakes and volcanoes to locate and determine the types of plate boundaries.	2
E3.4B	Describe how the sizes of earthquakes and volcanoes are measured or characterized.	1
E3.4C	Describe the effects of earthquakes and volcanic eruptions on humans.	1
E3.4d	Explain how the chemical composition of magmas relates to plate tectonics and affects the geometry, structure, and explosivity of volcanoes.	2
E3.4e	Explain how volcanoes change the atmosphere, hydrosphere, and other Earth systems.	1
E3.4f	Explain why fences are offset after an earthquake, using the elastic rebound theory.	2
Standard E4	**THE FLUID EARTH**	
Statement E4.p1	**Water Cycle *(prerequisite)*** Water circulates through the crust and atmosphere and in oceans, rivers, glaciers, and ice caps and connects all of the Earth systems. Groundwater is a significant reservoir and source of freshwater on Earth. The recharge and movement of groundwater depends on porosity, permeability, and the shape of the water table. The movement of groundwater occurs over a long period time. Groundwater and surface water are often interconnected *(prerequisite)*	
E4.p1A	Describe that the water cycle includes evaporation, transpiration, condensation, precipitation, infiltration, surface runoff, groundwater, and absorption. *(prerequisite)*	P
E4.p1B	Analyze the flow of water between the elements of a watershed, including surface features (lakes, streams, rivers, wetlands) and groundwater. *(prerequisite)*	P
E4.p1C	Describe the river and stream types, features, and process including cycles of flooding, erosion, and deposition as they occur naturally and as they are impacted by land use decisions. *(prerequisite)*	P
E4.p1D	Explain the types, process, and beneficial functions of wetlands.	P

HSCE Code	Expectation	DOK
Statement E4.p2	**Weather and the Atmosphere *(prerequisite)*** The atmosphere is divided into layers defined by temperature. Clouds are indicators of weather. *(prerequisite)*	
E4.p2A	Describe the composition and layers of the atmosphere *(prerequisite)*	P
E4.p2B	Describe the difference between weather and climate *(prerequisite)*	P
E4.p2C	Explain the differences between fog and dew formation and cloud formation *(prerequisite)*	P
E4.p2D	Describe relative humidity in terms of the moisture content of the air and the moisture capacity of the air and how these depend on the temperature. *(prerequisite)*	P
E4.p2E	Describe conditions associated with frontal boundaries (cold, warm, stationary, and occluded) *(prerequisite)*	P
E4.p2F	Describe the characteristics and movement across North America of the major air masses and the jet stream. *(prerequisite)*	P
E4.p2G	Interpret a weather map and describe present weather conditions and predict changes in weather over 24 hours *(prerequisite)*	P
E4.p2H	Explain the primary causes of seasons *(prerequisite)*	P
E4.p2I	Identify major global wind belts (trade winds, prevailing westerlies, and polar easterlies) and that their vertical components control the global distribution of rainforests and deserts. *(prerequisite)*	P
Statement E4.p3	**Glaciers *(prerequisite)*** Glaciers are large bodies of ice that move under the influence of gravity. They form part of both the rock and water cycles. Glaciers and ice sheets have shaped the landscape of the Great Lakes region. Areas that have been occupied by ice sheets are depressed. When the ice sheet is removed, the region rebounds (see also climate change). *(prerequisite)*	
E4.p3A	Describe how glaciers have affected the Michigan landscape and how the resulting landforms impact our state economy. *(prerequisite)*	P
E4.p3B	Explain what happens to the lithosphere when an ice sheet is removed. *(prerequisite)*	P
E4.p3C	Explain the formation of the Great Lakes. *(prerequisite)*	P
Statement E4.1	**Hydrogeology** Fresh water moves over time between the atmosphere, hydrosphere (surface water, wetlands, rivers, and glaciers), and geosphere (groundwater). Water resources are both critical to and greatly impacted by humans. Changes in water systems will impact quality, quantity, and movement of water. Natural surface water processes shape the landscape everywhere and are affected by human land use decisions.	
E4.1A	Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).	2
E4.1B	Explain the features and processes of groundwater systems and how the sustainability of North American aquifers has changed in recent history (e.g., the past 100 years) qualitatively using the concepts of recharge, residence time, inputs, and outputs.	2
E4.1C	Explain how water quality in both groundwater and surface systems is impacted by land use decisions	2
Statement E4.2	**Oceans and Climate** Energy from the Sun and the rotation of the Earth control global atmospheric circulation. Oceans redistribute matter and energy around the Earth through currents, waves, and interaction with other Earth systems. Ocean currents are controlled by prevailing winds, changes in water density, ocean topography, and the shape and location of landmasses. Oceans and large lakes (e.g., Great Lakes) have a major effect on climate and weather because they are a source of moisture and a large reservoir of heat. Interactions between oceanic circulation and the atmosphere can affect regional climates throughout the world.	

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E4.2A	Describe the major causes for the ocean's surface and deep water currents, including the prevailing winds, the Coriolis effect, unequal heating of the earth, changes in water temperature and salinity in high latitudes, and basin shape	1
E4.2B	Explain how interactions between the oceans and the atmosphere influence global and regional climate. Include the major concepts of heat transfer by ocean currents, thermohaline circulation, boundary currents, evaporation, precipitation, climatic zones, and the ocean as a major CO_2 reservoir.	2
E4.2c	Explain the dynamics (including ocean-atmosphere interactions) of the El Niño-Southern Oscillation (ENSO) and its effect on continental climates.	1
E4.2d	Identify factors affecting seawater density and salinity and describe how density affects oceanic layering and currents.	2
E4.2e	Explain the differences between maritime and continental climates with regard to oceanic currents.	2
E4.2f	Explain how the Coriolis effect controls oceanic circulation.	1
E4.r2g	Explain how El Niño affects economies (e.g., in South America). *(recommended)*	R
Statement E4.3	**Severe Weather** Tornadoes, hurricanes, blizzards, and thunderstorms are severe weather phenomena that impact society and ecosystems. Hazards include downbursts (wind shear), strong winds, hail, lightning, heavy rain, and flooding. The movement of air in the atmosphere is due to differences in air density resulting from variations in temperature. Many weather conditions can be explained by fronts that occur when air masses meet.	
E4.3A	Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).	1
E4.3B	Describe the damage resulting from and the social impact of thunderstorms, tornadoes, hurricanes, and floods	1
E4.3C	Describe severe weather and flood safety and mitigation.	1
E4.3D	Describe the seasonal variations in severe weather.	1
E4.3E	Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).	1
E4.3F	Describe how mountains, frontal wedging (including dry lines), convection, and convergence form clouds and precipitation.	1
E4.3g	Explain the process of adiabatic cooling and adiabatic temperature changes to the formation of clouds.	2
Standard E5	**THE EARTH IN SPACE AND TIME**	
Statement E5.p1	**Sky Observations *(prerequisite)*** Common sky observations (such as lunar phases) can be explained by the motion of solar system objects in regular and predictable patterns. Our galaxy, observable as the Milky Way, is composed of billions of stars, some of which have planetary systems. Seasons are a result of the tilt of the rotation axis of the Earth. The motions of the moon and Sun affect the phases of the moon and ocean tides. *(prerequisite)*	
E5.p1A	Describe the motions of various celestial bodies and some effects of those motions. *(prerequisite)*	P
E5.p1B	Explain the primary cause of seasons. *(prerequisite)*	P
E5.p1C	Explain how a light year can be used as a distance unit *(prerequisite)*	P
E5.p1D	Describe the position and motion of our solar system in our galaxy. *(prerequisite)*	P

HSCE Code	Expectation	DOK
Statement E5.1	**The Earth in Space** Scientific evidence indicates the universe is orderly in structure, finite, and contains all matter and energy Information from the entire light spectrum tells us about the composition and motion of objects in the universe Early in the history of the universe, matter clumped together by gravitational attraction to form stars and galaxies According to the Big Bang theory, the universe has been continually expanding at an increasing rate since its formation about 13.7 billion years ago.	
E5.1A	Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.	1
E5.1b	Describe how the Big Bang theory accounts for the formation of the universe	1
E5 1c	Explain how observations of the cosmic microwave background have helped determine the age of the universe.	1
E5 1d	Differentiate between the cosmological and Doppler red shift.	2
Statement E5.2	**The Sun** Stars, including the Sun, transform matter into energy in nuclear reactions When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy. Solar energy is responsible for life processes and weather as well as phenomena on Earth. These and other processes in stars have led to the formation of all the other chemical elements.	
E5.2A	Identify patterns in solar activities (sunspot cycle, solar flares, solar wind).	1
E5 2B	Relate events on the Sun to phenomena such as auroras, disruption of radio and satellite communications, and power grid disturbances.	1
E5 2C	Describe how nuclear fusion produces energy in the Sun	1
E5.2D	Describe how nuclear fusion and other processes in stars have led to the formation of all the other chemical elements.	1
Statement E5.2x	**Stellar Evolution** Stars, including the Sun, transform matter into energy in nuclear reactions When hydrogen nuclei fuse to form helium, a small amount of matter is converted to energy These and other processes in stars have led to the formation of all the other chemical elements There is a wide range of stellar objects of different sizes and temperatures. Stars have varying life histories based on these parameters.	
E5.2e	Explain how the Hertzsprung-Russell (H-R) diagram can be used to deduce other parameters (distance).	2
E5 2f	Explain how you can infer the temperature, life span, and mass of a star from its color. Use the H-R diagram to explain the life cycles of stars.	2
E5.2g	Explain how the balance between fusion and gravity controls the evolution of a star (equilibrium).	1
E5 2h	Compare the evolution paths of low-moderate-, and high-mass stars using the H-R diagram	2
Statement E5.3	**Earth History and Geologic Time** The solar system formed from a nebular cloud of dust and gas 4.6 Ga (billion years ago). The Earth has changed through time and has been affected by both catastrophic (e.g., earthquakes, meteorite impacts, volcanoes) and gradual geologic events (e g , plate movements, mountain building) as well as the effects of biological evolution (formation of an oxygen atmosphere). Geologic time can be determined through both relative and absolute dating.	
E5 3A	Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga (billion years ago).	1
E5.3B	Describe the process of radioactive decay and explain how radioactive elements are used to date the rocks that contain them.	1
E5.3C	Relate major events in the history of the Earth to the geologic time scale, including formation of the Earth, formation of an oxygen atmosphere, rise of life, Cretaceous-Tertiary (K-T) and Permian extinctions, and Pleistocene ice age.	1
E5.3D	Describe how index fossils can be used to determine time sequence.	1

HSCE Code	Expectation	DOK
Statement E5.3x	**Geologic Dating** Early methods of determining geologic time, such as the use of index fossils and stratigraphic principles, allowed for the relative dating of geological events. However, absolute dating was impossible until the discovery that certain radioactive isotopes in rocks have known decay rates, making it possible to determine how many years ago a given mineral or rock formed. Different kinds of radiometric dating techniques exist. Technique selection depends on the composition of the material to be dated, the age of the material, and the type of geologic event that affected the material.	
E5.3e	Determine the approximate age of a sample, when given the half-life of a radioactive substance (in graph or tabular form) along with the ratio of daughter to parent substances present in the sample.	2
E5.3f	Explain why C-14 can be used to date a 40,000 year old tree but U-Pb cannot.	2
E5.3g	Identify a sequence of geologic events using relative age dating principles.	2
Statement E5.4	**Climate Change** Atmospheric gases trap solar energy that has been reradiated from the Earth's surface (the greenhouse effect). The Earth's climate has changed both gradually and catastrophically over geological and historical time frames due to complex interactions between many natural variables and events. The concentration of greenhouse gases (especially carbon dioxide) has increased due to human industrialization which has contributed to a rise in average global atmospheric temperatures and changes in the biosphere, atmosphere, and hydrosphere. Climates of the past are researched, usually using indirect indicators, to better understand and predict climate change.	
E5.4A	Explain the natural mechanism of the greenhouse effect including comparisons of the major greenhouse gases (water vapor, carbon dioxide, methane, nitrous oxide, and ozone).	2
E5.4B	Describe natural mechanisms that could result in significant changes in climate (e.g., major volcanic eruptions, changes in sunlight received by the earth, meteorite impacts).	1
E5.4C	Analyze the empirical relationship between the emissions of carbon dioxide, atmospheric carbon dioxide levels and the average global temperature over the past 150 years.	2
E5.4D	Based on evidence of observable changes in recent history and climate change models, explain the consequences of warmer oceans (including the results of increased evaporation, shoreline and estuarine impacts, oceanic algae growth, and coral bleaching) and changing climatic zones (including the adaptive capacity of the biosphere).	2
E5.4e	Based on evidence from historical climate research (e.g., fossils, varves, ice core data) and climate change models, explain how the current melting of polar ice caps can impact the climatic system .	2
E5.4f	Describe geologic evidence that implies climates were significantly colder at times in the geologic record (e.g., geomorphology, striations, and fossils).	1
E5.4g	Compare and contrast the heat-trapping mechanisms of the major greenhouse gases resulting from emissions (carbon dioxide, methane, nitrous oxide, fluorocarbons) as well as their abundance and heat trapping capacity.	2
E5.r4h	Use oxygen isotope data to estimate paleotemperature. *(recommended)*	R
E5.r4i	Explain the causes of short-term climate changes such as catastrophic volcanic eruptions and impact of solar system objects. *(recommended)*	R
E5.r4j	Predict the global temperature increase by 2100, given data on the annual trends of CO_2 concentration increase. *(recommended)*	R

HSCE Code	Expectation	DOK
Standard P1	**INQUIRY, REFLECTION, AND SOCIAL IMPLICATIONS**	
Statement P1.1	**Scientific Inquiry** Science is a way of understanding nature. Scientific research may begin by generating new scientific questions that can be answered through replicable scientific investigations that are logically developed and conducted systematically. Scientific conclusions and explanations result from careful analysis of empirical evidence and the use of logical reasoning. Some questions in science are addressed through indirect rather than direct observation, evaluating the consistency of new evidence with results predicted by models of natural processes. Results from investigations are communicated in reports that are scrutinized through a peer review process.	
P1.1A	Generate new questions that can be investigated in the laboratory or field.	3
P1.1B	Evaluate the uncertainties or validity of scientific conclusions using an understanding of sources of measurement error, the challenges of controlling variables, accuracy of data analysis, logic of argument, logic of experimental design, and/or the dependence on underlying assumptions.	3
P1.1C	Conduct scientific investigations using appropriate tools and techniques (e.g., selecting an instrument that measures the desired quantity–length, volume, weight, time interval, temperature–with the appropriate level of precision).	2
P1.1D	Identify patterns in data and relate them to theoretical models.	2
P1.1E	Describe a reason for a given conclusion using evidence from an investigation.	3
P1.1f	Predict what would happen if the variables, methods, or timing of an investigation were changed.	3
P1.1g	Based on empirical evidence, explain and critique the reasoning used to draw a scientific conclusion or explanation.	3
P1.1h	Design and conduct a systematic scientific investigation that tests a hypothesis. Draw conclusions from data presented in charts or tables.	3
P1.1i	Distinguish between scientific explanations that are regarded as current scientific consensus and the emerging questions that active researchers investigate.	2
Statement P1.2	**Scientific Reflection and Social Implications** The integrity of the scientific process depends on scientists and citizens understanding and respecting the "Nature of Science." Openness to new ideas, skepticism, and honesty are attributes required for good scientific practice. Scientists must use logical reasoning during investigation design, analysis, conclusion, and communication. Science can produce critical insights on societal problems from a personal and local scale to a global scale. Science both aids in the development of technology and provides tools for assessing the costs, risks, and benefits of technological systems. Scientific conclusions and arguments play a role in personal choice and public policy decisions. New technology and scientific discoveries have had a major influence in shaping human history. Science and technology continue to offer diverse and significant career opportunities.	
P1.2A	Critique whether or not specific questions can be answered through scientific investigations.	3
P1.2B	Identify and critique arguments about personal or societal issues based on scientific evidence	3
P1.2C	Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.	3
P1.2D	Evaluate scientific explanations in a peer review process or discussion format	3
P1.2E	Evaluate the future career and occupational prospects of science fields.	2
P1.2f	Critique solutions to problems, given criteria and scientific constraints.	3
P1.2g	Identify scientific tradeoffs in design decisions and choose among alternative solutions	2
P1.2h	Describe the distinctions between scientific theories, laws, hypotheses, and observations.	2
P1.2i	Explain the progression of ideas and explanations that lead to science theories that are part of the current scientific consensus or core knowledge.	2
P1.2j	Apply science principles or scientific data to anticipate effects of technological design decisions.	3
P1.2k	Analyze how science and society interact from a historical, political, economic, or social perspective.	2

HSCE Code	Expectation	DOK
Standard P2	**MOTION OF OBJECTS**	
Statement P2.1	**Position — Time** An object's position can be measured and graphed as a function of time. An object's speed can be calculated and graphed as a function of time.	
P2.1A	Calculate the average speed of an object using the change of position and elapsed time.	1
P2.1B	Represent the velocities for linear and circular motion using motion diagrams (arrows on strobe pictures).	1
P2.1C	Create line graphs using measured values of position and elapsed time.	2
P2.1D	Describe and analyze the motion that a position-time graph represents, given the graph.	2
P2.1E	Describe and classify various motions in a plane as one dimensional, two dimensional, circular, or periodic.	2
P2.1F	Distinguish between rotation and revolution and describe and contrast the two speeds of an object like the Earth.	2
P2.1g	Solve problems involving average speed and constant acceleration in one dimension.	1
P2.1h	Identify the changes in speed and direction in everyday examples of circular (rotation and revolution), periodic, and projectile motions.	1
Statement P2.2	**Velocity — Time** The motion of an object can be described by its position and velocity as functions of time and by its average speed and average acceleration during intervals of time.	
P2.2A	Distinguish between the variables of distance, displacement, speed, velocity, and acceleration.	1
P2.2B	Use the change of speed and elapsed time to calculate the average acceleration for linear motion.	1
P2.2C	Describe and analyze the motion that a velocity-time graph represents, given the graph.	2
P2.2D	State that uniform circular motion involves acceleration without a change in speed.	1
P2.2e	Use the area under a velocity-time graph to calculate the distance traveled and the slope to calculate the acceleration.	2
P2.2f	Describe the relationship between changes in position, velocity, and acceleration during periodic motion.	2
P2.2g	Apply the independence of the vertical and horizontal initial velocities to solve projectile motion problems.	2
Statement P2.3x	**Frames of Reference** All motion is relative to whatever frame of reference is chosen, for there is no motionless frame from which to judge all motion.	
P2.3a	Describe and compare the motion of an object using different reference frames.	2
Standard P3	**FORCES AND MOTION**	
Statement P3.1	**Basic Forces in Nature** Objects can interact with each other by "direct contact" (pushes or pulls, friction) or at a distance (gravity, electromagnetism, nuclear).	
P3.1A	Identify the force(s) acting between objects in "direct contact" or at a distance.	1
Statement P3.1x	**Forces** There are four basic forces (gravitational, electromagnetic, strong, and weak nuclear) that differ greatly in magnitude and range. Between any two charged particles, electric force is vastly greater than the gravitational force. Most observable forces (e.g., those exerted by a coiled spring or friction) may be traced to electric forces acting between atoms and molecules.	
P3.1b	Explain why scientists can ignore the gravitational force when measuring the net force between two electrons.	1
P3.1c	Provide examples that illustrate the importance of the electric force in everyday life.	1
P3.1d	Identify the basic forces in everyday interactions.	1
Statement P3.2	**Net Forces** Forces have magnitude and direction. The net force on an object is the sum of all the forces acting on the object. Objects change their speed and/or direction only when a net force is applied. If the net force on an object is zero, there is no change in motion (Newton's First Law).	
P3.2A	Identify the magnitude and direction of everyday forces (e.g., wind, tension in ropes, pushes and pulls, weight).	1
P3.2B	Compare work done in different situations.	2
P3.2C	Calculate the net force acting on an object	1
P3.2d	Calculate all the forces on an object on an inclined plane and describe the object's motion based on the forces using free-body diagrams.	2

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Statement P3.3	**Newton's Third Law** Whenever one object exerts a force on another object, a force equal in magnitude and opposite in direction is exerted back on the first object.	
P3.3A	Identify the action and reaction force from examples of forces in everyday situations (e.g., book on a table, walking across the floor, pushing open a door)	1
P3.3b	Predict how the change in velocity of a small mass compares to the change in velocity of a large mass when the objects interact (e.g., collide).	2
P3.3c	Explain the recoil of a projectile launcher in terms of forces and masses.	1
P3.3d	Analyze why seat belts may be more important in autos than in buses.	2
Statement P3.4	**Forces and Acceleration** The change of speed and/or direction (acceleration) of an object is proportional to the net force and inversely proportional to the mass of the object. The acceleration and net force are always in the same direction.	
P3.4A	Predict the change in motion of an object acted on by several forces.	2
P3.4B	Identify forces acting on objects moving with constant velocity (e.g., cars on a highway).	1
P3.4C	Solve problems involving force, mass, and acceleration in linear motion (Newton's second law)	1
P3.4D	Identify the force(s) acting on objects moving with uniform circular motion (e.g., a car on a circular track, satellites in orbit).	1
P3.4e	Solve problems involving force, mass, and acceleration in two-dimensional projectile motion restricted to an initial horizontal velocity with no initial vertical velocity (e.g., a ball rolling off a table).	1
P3.4f	Calculate the changes in velocity of a thrown or hit object during and after the time it is acted on by the force.	1
P3.4g	Explain how the time of impact can affect the net force (e.g., air bags in cars, catching a ball).	1
Statement P3.5x	**Momentum** A moving object has a quantity of motion (momentum) that depends on its velocity and mass. In interactions between objects, the total momentum of the objects does not change.	
P3.5a	Apply conservation of momentum to solve simple collision problems.	1
Statement P3.6	**Gravitational Interactions** Gravitation is an attractive force that a mass exerts on every other mass. The strength of the gravitational force between two masses is proportional to the masses and inversely proportional to the square of the distance between them.	
P3.6A	Explain earth-moon interactions (orbital motion) in terms of forces.	1
P3.6B	Predict how the gravitational force between objects changes when the distance between them changes.	1
P3.6C	Explain how your weight on Earth could be different from your weight on another planet.	1
P3.6d	Calculate force, masses, or distance, given any three of these quantities, by applying the Law of Universal Gravitation, given the value of G.	1
P3.6e	Draw arrows (vectors) to represent how the direction and magnitude of a force changes on an object in an elliptical orbit.	1
Statement P3.7	**Electric Charges** Electric force exists between any two charged objects. Oppositely charged objects attract, while objects with like charge repel. The strength of the electric force between two charged objects is proportional to the magnitudes of the charges and inversely proportional to the square of the distance between them (Coulomb's Law).	
P3.7A	Predict how the electric force between charged objects varies when the distance between them and/or the magnitude of charges change.	1
P3.7B	Explain why acquiring a large excess static charge (e.g., pulling off a wool cap, touching a Van de Graaff generator, combing) affects your hair.	1
Statement P3.7x	**Electric Charges — Interactions** Charged objects can attract electrically neutral objects by induction.	
P3.7c	Draw the redistribution of electric charges on a neutral object when a charged object is brought near	1
P3.7d	Identify examples of induced static charges.	1
P3.7e	Explain why an attractive force results from bringing a charged object near a neutral object.	1
P3.7f	Determine the new electric force on charged objects after they touch and are then separated.	1
P3.7g	Propose a mechanism based on electric forces to explain current flow in an electric circuit.	1

HSCE Code	Expectation	DOK
Statement P3.p8	**Magnetic Force (prerequisite)** Magnets exert forces on all objects made of ferromagnetic materials (e.g., iron, cobalt, and nickel) as well as other magnets. This force acts at a distance. Magnetic fields accompany magnets and are related to the strength and direction of the magnetic force. *(prerequisite)*	
P3.p8A	Create a representation of magnetic field lines around a bar magnet and qualitatively describe how the relative strength and direction of the magnetic force changes at various places in the field. *(prerequisite)*	P
Statement P3.8x	**Electromagnetic Force** Magnetic and electric forces are two aspects of a single electromagnetic force. Moving electric charges produce magnetic forces and moving magnets produce electric forces (e.g., electric current in a conductor).	
P3.8b	Explain how the interaction of electric and magnetic forces is the basis for electric motors, generators, and the production of electromagnetic waves.	1
Standard P4	**FORMS OF ENERGY AND ENERGY TRANSFORMATIONS**	
Statement P4.1	**Energy Transfer** Moving objects and waves transfer energy from one location to another. They also transfer energy to objects during interactions (e.g., sunlight transfers energy to the ground when it warms the ground; sunlight also transfers energy from the sun to the Earth).	
P4.1A	Account for and represent energy into and out of systems using energy transfer diagrams.	2
P4.1B	Explain instances of energy transfer by waves and objects in everyday activities (e.g., why the ground gets warm during the day, how you hear a distant sound, why it hurts when you are hit by a baseball).	1
Statement P4.1x	**Energy Transfer — Work** Work is the amount of energy transferred during an interaction. In mechanical systems, work is the amount of energy transferred as an object is moved through a distance, $W = F\ d$, where d is in the same direction as F. The total work done on an object depends on the net force acting on the object and the object's displacement.	
P4.1c	Explain why work has a more precise scientific meaning than the meaning of work in everyday language.	1
P4.1d	Calculate the amount of work done on an object that is moved from one position to another.	1
P4.1e	Using the formula for work, derive a formula for change in potential energy of an object lifted a distance h.	1
Statement P4.2	**Energy Transformation** Energy is often transformed from one form to another. The amount of energy before a transformation is equal to the amount of energy after the transformation. In most energy transformations, some energy is converted to thermal energy.	
P4.2A	Account for and represent energy transfer and transformation in complex processes (interactions)	2
P4.2B	Name devices that transform specific types of energy into other types (e.g., a device that transforms electricity into motion).	1
P4.2C	Explain how energy is conserved in common systems (e.g., light incident on a transparent material, light incident on a leaf, mechanical energy in a collision)	1
P4.2D	Explain why all the stored energy in gasoline does not transform to mechanical energy of a vehicle.	1
P4.2e	Explain the energy transformation as an object (e.g., skydiver) falls at a steady velocity.	1
P4.2f	Identify and label the energy inputs, transformations, and outputs using qualitative or quantitative representations in simple technological systems (e.g., toaster, motor, hair dryer) to show energy conservation.	1
Statement P4.3	**Kinetic and Potential Energy** Moving objects have kinetic energy. Objects experiencing a force may have potential energy due to their relative positions (e.g., lifting an object or stretching a spring, energy stored in chemical bonds). Conversions between kinetic and gravitational potential energy are common in moving objects. In frictionless systems, the decrease in gravitational potential energy is equal to the increase in kinetic energy or vice versa.	
P4.3A	Identify the form of energy in given situations (e.g., moving objects, stretched springs, rocks on cliffs, energy in food).	1

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P4.3B	Describe the transformation between potential and kinetic energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts).	1
P4.3C	Explain why all mechanical systems require an external energy source to maintain their motion	1
Statement P4.3x	**Kinetic and Potential Energy — Calculations** The kinetic energy of an object is related to the mass of an object and its speed: $KE = 1/2\ mv2$.	
P4.3d	Rank the amount of kinetic energy from highest to lowest of everyday examples of moving objects	2
P4.3e	Calculate the changes in kinetic and potential energy in simple mechanical systems (e.g., pendulums, roller coasters, ski lifts) using the formulas for kinetic energy and potential energy.	1
P4.3f	Calculate the impact speed (ignoring air resistance) of an object dropped from a specific height or the maximum height reached by an object (ignoring air resistance), given the initial vertical velocity.	1
Statement P4.4	**Wave Characteristics** Waves (mechanical and electromagnetic) are described by their wavelength, amplitude, frequency, and speed.	
P4.4A	Describe specific mechanical waves (e.g., on a demonstration spring, on the ocean) in terms of wavelength, amplitude, frequency, and speed.	1
P4.4B	Identify everyday examples of transverse and compression (longitudinal) waves	1
P4.4C	Compare and contrast transverse and compression (longitudinal) waves in terms of wavelength, amplitude, and frequency.	2
Statement P4.4x	**Wave Characteristics — Calculations** Wave velocity, wavelength, and frequency are related by $v = \lambda f$. The energy transferred by a wave is proportional to the square of the amplitude of vibration and its frequency.	
P4.4d	Demonstrate that frequency and wavelength of a wave are inversely proportional in a given medium.	1
P4.4e	Calculate the amount of energy transferred by transverse or compression waves of different amplitudes and frequencies (e.g., seismic waves).	1
Statement P4.5	**Mechanical Wave Propagation** Vibrations in matter initiate mechanical waves (e.g., water waves, sound waves, seismic waves), which may propagate in all directions and decrease in intensity in proportion to the distance squared for a point source Waves transfer energy from one place to another without transferring mass.	
P4.5A	Identify everyday examples of energy transfer by waves and their sources	1
P4.5B	Explain why an object (e.g., fishing bobber) does not move forward as a wave passes under it.	1
P4.5C	Provide evidence to support the claim that sound is energy transferred by a wave, not energy transferred by particles.	2
2P4.5D	Explain how waves propagate from vibrating sources and why the intensity decreases with the square of the distance from a point source	2
P14.5E	Explain why everyone in a classroom can hear one person speaking, but why an amplification system is often used in the rear of a large concert auditorium.	1
Statement P4.6	**Electromagnetic Waves** Electromagnetic waves (e.g., radio, microwave, infrared, visible light, ultraviolet, x-ray) are produced by changing the motion (acceleration) of charges or by changing magnetic fields. Electromagnetic waves can travel through matter, but they do not require a material medium. (That is, they also travel through empty space.) All electromagnetic waves move in a vacuum at the speed of light. Types of electromagnetic radiation are distinguished from each other by their wavelength and energy.	
P4.6A	Identify the different regions on the electromagnetic spectrum and compare them in terms of wavelength, frequency, and energy.	2
P4.6B	Explain why radio waves can travel through space, but sound waves cannot	1

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P4.6C	Explain why there is a time delay between the time we send a radio message to astronauts on the moon and when they receive it.	1
P4.6D	Explain why we see a distant event before we hear it (e.g., lightning before thunder, exploding fireworks before the boom).	1
Statement P4.6x	**Electromagnetic Propagation** Modulated electromagnetic waves can transfer information from one place to another (e.g., televisions, radios, telephones, computers and other information technology devices). Digital communication makes more efficient use of the limited electromagnetic spectrum, is more accurate than analog transmission, and can be encrypted to provide privacy and security.	
P4.6e	Explain why antennas are needed for radio, television, and cell phone transmission and reception	1
P4.6f	Explain how radio waves are modified to send information in radio and television programs, radio-control cars, cell phone conversations, and GPS systems.	1
P4.6g	Explain how different electromagnetic signals (e.g., radio station broadcasts or cell phone conversations) can take place without interfering with each other.	1
P4.6h	Explain the relationship between the frequency of an electromagnetic wave and its technological uses.	1
Statement P4.r7x	**Quantum Theory of Waves *(recommended)*** Electromagnetic energy is transferred on the atomic scale in discrete amounts called quanta. The equation $E = hf$ quantifies the relationship between the energy transferred and the frequency, where h is Planck's constant *(recommended)*	
P4.r7a	Calculate and compare the energy in various electromagnetic quanta (e.g., visible light, x-rays) *(recommended)*.	R
Statement P4.8	**Wave Behavior — Reflection and Refraction** The laws of reflection and refraction describe the relationships between incident and reflected/refracted waves.	
P4.8A	Draw ray diagrams to indicate how light reflects off objects or refracts into transparent media.	1
P4.8B	Predict the path of reflected light from flat, curved, or rough surfaces (e.g., flat and curved mirrors, painted walls, paper).	1
Statement P4.8x	**Wave Behavior — Diffraction, Interference, and Refraction** Waves can bend around objects (diffraction). They also superimpose on each other and continue their propagation without a change in their original properties (interference). When refracted, light follows a defined path.	
P4.8c	Describe how two wave pulses propagated from opposite ends of a demonstration spring interact as they meet	1
P4.8d	List and analyze everyday examples that demonstrate the interference characteristics of waves (e.g., dead spots in an auditorium, whispering galleries, colors in a CD, beetle wings).	1
P4.8e	Given an angle of incidence and indices of refraction of two materials, calculate the path of a light ray incident on the boundary (Snell's Law).	1
P4.8f	Explain how Snell's Law is used to design lenses (e.g., eye glasses, microscopes, telescopes, binoculars).	1
Statement P4.9	**Nature of Light** Light interacts with matter by reflection, absorption, or transmission.	
P4.9A	Identify the principle involved when you see a transparent object (e.g., straw, a piece of glass) in a clear liquid.	1
P4.9B	Explain how various materials reflect, absorb, or transmit light in different ways.	1
P4.9C	Explain why the image of the Sun appears reddish at sunrise and sunset.	1
Statement P4.r9x	**Nature of Light — Wave-Particle Nature *(recommended)*** The dual wave-particle nature of matter and light is the foundation for modern physics. *(recommended)*	
P4.r9d	Describe evidence that supports the dual wave particle nature of light. *(recommended)*	R
Statement P4.10	**Current Electricity — Circuits** Current electricity is described as movement of charges. It is a particularly useful form of energy because it can be easily transferred from place to place and readily transformed by various devices into other forms of energy (e.g., light, heat, sound, and motion). Electrical current (amperage) in a circuit is determined by the potential difference (voltage) of the power source and the resistance of the loads in the circuit.	

HSCE Code	Expectation	DOK
P4 10A	Describe the energy transformations when electrical energy is produced and transferred to homes and businesses.	1
P4 10B	Identify common household devices that transform electrical energy to other forms of energy, and describe the type of energy transformation.	1
P4 10C	Given diagrams of many different possible connections of electric circuit elements, identify complete circuits, open circuits, and short circuits and explain the reasons for the classification.	2
P4.10D	Discriminate between voltage, resistance, and current as they apply to an electric circuit.	2
Statement P4.10x	**Current Electricity — Ohm's Law, Work, and Power** In circuits, the relationship between electric current, I, electric potential difference, V, and resistance, R, is quantified by $V = I R$ (Ohm's Law). Work is the amount of energy transferred during an interaction. In electrical systems, work is done when charges are moved through the circuit. Electric power is the amount of work done by an electric current in a unit of time, which can be calculated using $P = I V$.	
P4.10e	Explain energy transfer in a circuit, using an electrical charge model.	1
P4.10f	Calculate the amount of work done when a charge moves through a potential difference, V.	1
P4.10g	Compare the currents, voltages, and power in parallel and series circuits.	2
P4.10h	Explain how circuit breakers and fuses protect household appliances.	1
P4 10i	Compare the energy used in one day by common household appliances (e.g., refrigerator, lamps, hair dryer, toaster, televisions, music players).	2
P4.10j	Explain the difference between electric power and electric energy as used in bills from an electric company.	2
Statement P4.11x	**Heat, Temperature, and Efficiency** Heat is often produced as a by-product during energy transformations. This energy is transferred into the surroundings and is not usually recoverable as a useful form of energy. The efficiency of systems is defined as the ratio of the useful energy output to the total energy input. The efficiency of natural and human-made systems varies due to the amount of heat that is not recovered as useful work.	
P4.11a	Calculate the energy lost to surroundings when water in a home water heater is heated from room temperature to the temperature necessary to use in a dishwasher, given the efficiency of the home hot water heater.	1
P4 11b	Calculate the final temperature of two liquids (same or different materials) at the same or different temperatures and masses that are combined.	1
Statement P4.12	**Nuclear Reactions** Changes in atomic nuclei can occur through three processes: fission, fusion, and radioactive decay. Fission and fusion can convert small amounts of matter into large amounts of energy. Fission is the splitting of a large nucleus into smaller nuclei at extremely high temperature and pressure. Fusion is the combination of smaller nuclei into a large nucleus and is responsible for the energy of the Sun and other stars. Radioactive decay occurs naturally in the Earth's crust (rocks, minerals) and can be used in technological applications (e.g., medical diagnosis and treatment).	
P4.12A	Describe peaceful technological applications of nuclear fission and radioactive decay.	1
P4.12B	Describe possible problems caused by exposure to prolonged radioactive decay.	1
P4.12C	Explain how stars, including our Sun, produce huge amounts of energy (e.g., visible, infrared, or ultraviolet light).	1
Statement P4.12x	**Mass and Energy** In nuclear reactions, a small amount of mass is converted to a large amount of energy, $E = mc2$, where c is the speed of light in a vacuum. The amount of energy before and after nuclear reactions must consider mass changes as part of the energy transformation.	
P4.12d	Identify the source of energy in fission and fusion nuclear reactions.	1